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NAVAL NUCLEAR PROPULSION PROGRAM—1985

HEARING

ON

H.R. 1873

[H.R. 1872, TITLE IX]

DEPARTMENT OF ENERGY AUTHORIZATION LEGISLATION (NATIONAL SECURITY PROGRAMS) FOR FISCAL YEAR 1986

BEFORE THE

PROCUREMENT AND MILITARY NUCLEAR SYSTEMS SUBCOMMITTEE

OF THE

COMMITTEE ON ARMED SERVICES HOUSE OF REPRESENTATIVES

NINETY-NINTH CONGRESS

FIRST SESSION

FEBRUARY 22, 1985

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CONTENTS

	Page
Introductory remarks	1
Summary of 1984 operations	1
Retention	2
Soviet developments	2
Personnel characteristics	3
Naval nuclear training	5
Naval reactor characteristics	6
Training on operating reactors	7
Headquarters personnel	9
Officer accessions	9
Fleet operations	10
Budget outline	11
Adequacy of competition	11
Industrial base	13
Control of technical data	14
Design standardization	15
Budget change	16
Dangers of overextending vendor base	17
Reactor core life	18
Fuel manufacturing facility	19
Use of simulators in training reactor plant operators	19
SSN-21 Propulsion Plant	20
Submarine disposal	20
Soviet submarines	21
Submarine construction	22
Improvements to U.S. submarines	22
Reactor component costs	23

APPENDIXES

A. Prepared statement of Adm. Kinnaird R. McKee	25
Introduction	25
Submarine programs	25
Surface warships	26
Operations	27
New development	29
Naval personnel	30
Shipboard perspective	32
Nuclear training	32
Commanding officers	34
Headquarters personnel	35
Summary	35
Budget	36
Fiscal year 1986 Department of Energy budget request for the Naval Reactors Development Program	37
Reactor development	40
Capital equipment	41
Construction	42
Plant development	42
Reactor operation and evaluation	43
Program direction	44
B. Review of responsibilities and authorities of the Office of Naval Reactors, Department of Energy for overseeing naval nuclear propulsion activities in the Department of Defense	46

Page

B. Review of responsibilities and authorities of the Office of Naval Reactors, Department of Energy for overseeing naval nuclear propulsion activities in the Department of Defense—Continued
Atomic Energy Act of 1954 ... 46
Energy Reorganization Act of 1974 ... 49
DOE Organization Act of 1977 ... 50
Executive Order 12344 of February 1, 1982 ... 50
Relationship with other DOE offices ... 52
Relationship with other Navy offices ... 53
Conclusion ... 55
Memo to Deputy Director, Office of Nuclear Reactor Regulation to Executive Legal Director, Subject: NRC obligation to provide technical advice on health and safety matters concerning Navy Nuclear Propulsion Reactors when requested by DOD ... 56
Presidential Executive Order 12344 ... 65
Strengthening of the DOE HQ Independent Safety Organization ... 67
C. Environmental monitoring and disposal of radioactive waters from U.S. Naval nuclear powered ships and their support facilities ... 72
Summary ... 76
Radioative liquid waste processing and control ... 78
Policy and procedures minimizing release of radioactivity in harbors ... 78
Source of radioactivity ... 78
Radioactivity removal from liquid wastes at shore facilities ... 79
Liquid waste releases in habors ... 79
Short-lived radionuclides ... 81
Fission product radionuclides ... 81
Tritium ... 82
Carbon 14 ... 83
Liquid waste releases at sea ... 83
Loss of U.S.S. *Thresher* and U.S.S. *Scorpion* ... 84
Solid radioactive waste disposal ... 86
Deactivation of Ingalls shipbuilding radiological facilities ... 88
Transportation of radioactive material ... 90
Environmental monitoring ... 94
Navy Environmental Monitoring Program ... 94
Environmental pathways analysis ... 101
Audits and reviews ... 107
Conclusions ... 109
References ... 110

List of Tables

Table 1.—Radioactive liquid waste released to harbors from U.S naval nuclear-powered ships and their support facilities ... 77
Table 2.—Total radioactivity in liquid waste released at sea originating from U.S. naval nuclear-powered ships ... 84
Table 3.—Radioactive solid waste from U.S. naval nuclear-powered ships and their support facilities for 1980 through 1984 ... 87
Table 4.—Summary of 1984 surveys for cobalt 60 in bottom sediment of U.S. habors where U.S. naval nuclear-powered ships have been regularly based, overhauled or built ... 97
Table 5.—Radionuclide releases assumed for environmental pathways analysis ... 104
Table 6.—Environmental exposure times, consumption and concentration parameters assumed for environmental pathways analysis ... 105
Table 7.—Estimated maximum radiation exposure to an individual for assumed liquid and airborne radioactivity releases from shipyards engaged in naval nuclear propulsion work ... 106
Table 8.—Estimated total whole body radiation exposure to general public within 50 miles for assumed liquid and airborne radioactivity releases from shipyards engaged in naval nuclear propulsion plant work ... 106

List of Figures

Figure 1.—Simplified diagram of waste processing system ... 80
Figure 2.—Radioactive solid waste disposal volumes in the Naval Nuclear Propulsion Program, 1961-84 ... 89

Page

C. Environmental monitoring and disposal of radioactive waters from U.S. Naval nuclear powered ships and their support facilities—Continued
Figure 3.—Dredge for sampling harbor sediment 96
Figure 4.—Gamma spectra of harbor bottom sediment samples with lithium-drifted germanium detector 103
Figure 5.—Pathways for external and internal exposure of man from airborne and liquid releases of radioactivity 103
Appendix environmental monitoring survey charts 115
D. Occupational radiation exposure from U.S. naval nuclear propulsion plants and their support facilities 140

Table of Contents

Summary 143
External radiation exposure 145
Policy and limits 145
Source of radiation 146
Control of radiation during reactor plant operation 147
Control of radiation in support facilities 147
Dosimetry 148
Physical examinations 151
Shipyard, tender, and submarine base training 152
Nuclear power training 156
Radiation exposure reduction 156
Radiation exposure data 159
Internal radioactivity 169
Policy and limits 169
Source of radioactivity 169
Control of airborne radioactivity 170
Control of radioactive surface contamination 171
Control of food and water 172
Wounds 172
Monitoring for internal radioactivity 173
Results of internal monitoring in 1983 174
Effects of radiation on personnel 175
Exposure to radiation involves some risk 175
Studies of the effects of radiation on humans 176
Numerical estimates of risk from radiation 178
Radiation exposure comparisons 180
Extrapolations 182
Conclusions on the effects of radiation on personnel 183
Claims for radiation injury to personnel 184
Audits and reviews 186
Abnormal occurrences 188
References 190

List of Figures

Figure 1.—Total radiation exposure received by military and civilian personnel in the Naval Nuclear Propulsion Program 1960–84 144
Figure 2.—Total radiation exposure received by shipyard personnel from work associated with naval nuclear propulsion plants 1958–84 165

List of Tables

Table 1.—Shipyard first reactor plant operation and first radioactive overhaul work 162
Table 2.—Occupational radiation exposure received by personnel assigned to tenders, bases, and nuclear-powered ships from operation and maintenance of naval nuclear propulsion plants 163
Table 3.—Occupational radiation exposure received by shipyard personnel from work associated with naval nuclear propulsion plants 164
Table 4.—Shipyard and fleet distribution of personnel radiation exposure 166
Table 5.—Distribution of total lifetime radiation exposure associated with naval nuclear propulsion plants 167
Table 6.—Personnel radiation exposure for commercial nuclear power reactors licensed by U.S. Nuclear Regulatory Commission 168

Page

D. Occupational radiation exposure from U.S. naval nuclear propulsion plants and their support facilities—Continued
Table 7.—Claims for radiation injury to personnel 185
Table 8.—Abnormal occurrences in the Naval Nuclear Propulsion Program 189

99TH CONGRESS
1ST SESSION

H. R. 1873

To authorize appropriations for the Department of Energy for national security programs for fiscal year 1986 and fiscal year 1987, and for other purposes.

IN THE HOUSE OF REPRESENTATIVES

APRIL 2, 1985

Mr. STRATTON (for himself and Mrs. HOLT) (by request) introduced the following bill; which was referred to the Committee on Armed Services

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A BILL

To authorize appropriations for the Department of Energy for national security programs for fiscal year 1986 and fiscal year 1987, and for other purposes.

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled, That this Act may be cited as the "National Security Programs Authorization Act for Fiscal Years 1986 and 1987".

TITLE I—NATIONAL SECURITY PROGRAMS

OPERATING EXPENSES

SEC. 101. Funds are authorized to be appropriated to the Department of Energy for fiscal year 1986 for operating expenses incurred in carrying out national security programs (including scientific research and development in support of

the Armed Forces, strategic and critical materials necessary for the common defense, and military applications of nuclear energy and related management and support activities) as follows:

(1) For weapons activities, $3,505,400,000.

(2) For materials production, $1,616,300,000.

(3) For defense waste and byproducts management, $405,122,000.

(4) For verification and control technology, $83,475,000.

(5) For nuclear safeguards and security, $54,325,000.

(6) For security investigations, $33,400,000.

(7) For naval reactors development, $489,000,000.

* * * * * * *

NAVAL NUCLEAR PROPULSION PROGRAM—1985

HOUSE OF REPRESENTATIVES,
COMMITTEE ON ARMED SERVICES,
PROCUREMENT AND MILITARY
NUCLEAR SYSTEMS SUBCOMMITTEE,
Washington, DC, Friday, February 22, 1985.

The subcommittee met, pursuant to call, at 10 a.m., in room 2118, Rayburn House Office Building, Hon. Samuel S. Stratton (chairman of the subcommittee) presiding.

OPENING STATEMENT OF HON. SAMUEL S. STRATTON, A REPRESENTATIVE FROM NEW YORK, CHAIRMAN, PROCUREMENT AND MILITARY NUCLEAR SYSTEMS SUBCOMMITTEE

INTRODUCTORY REMARKS

Mr. STRATTON. The subcommittee will come to order.

Under authority granted to the chairman on the 20th of February, the subcommittee will now go into closed session for national security reasons.

The Chair welcomes Admiral McKee, who will give us his report on the Naval Nuclear Reactors Program with which he is charged.

I know we are glad to have you with us again and appreciate your proceeding in any way you see fit.

STATEMENT OF ADM. KINNAIRD R. McKEE, DEPUTY ASSISTANT SECRETARY FOR NAVAL REACTORS, DEPARTMENT OF ENERGY, AND DIRECTOR, NAVAL NUCLEAR PROPULSION PROGRAM, NAVAL SEA SYSTEMS COMMAND, DEPARTMENT OF DEFENSE

Admiral MCKEE. Thank you, Mr. Chairman.

I have, as you know, submitted several pages of prepared testimony. What I would propose to do is not read that back to you but simply get up and start talking about my program, if that would be all right.

Mr. STRATTON. That is certainly agreeable.

SUMMARY OF 1984 OPERATIONS

Admiral MCKEE. What I would like to do is take you through some of the areas I didn't spend very much time with last year.

If you recall, most of my testimony last year was devoted to a very highly classified subject, submarine special operations. And the issue was how do we know where we are with regard to the other guy. We also talked about what it means to use the submarine and the military forces for leverage. We talked about the sub-

marine and what sort of work we had to do in 1985 in order to bring these things to pass. But the focus of discussion was almost entirely on operations and on technical subjects.

This is just to bring you up to date as to where we are. During the past 12 months we have built up to 172 operating reactors. That is the largest operating reactor program in the free world. Six U.S. nuclear submarines were commissioned last year. That is neat. That is more than we had authorized for that year. But as you know, Mr. Chairman, we are catching up from that terrible backlog of submarine building back in the late seventies and early eighties.

Five more submarines were authorized in 1984. We launched a nuclear-powered aircraft carrier, the *Theodore Roosevelt.* The new attack submarine preliminary design work is nearing completion and contract design will start perhaps sometime in the summer. We have selected the design of the reactor core for the new plant, and are moving in that direction.

We are also moving toward completion of the design of the moored training ship. You remember that the moored training ship is a submarine that will be taken out of commission and used to train naval reactor operators. I will talk more about that later. The Congress was kind enough to give us the money to get a headstart on this one, and that is very important.

During 1984 our nuclear powered ships traveled another 5 million miles, and we trained another 3,200 operators. One of our attack submarines, *Dallas,* deployed and steamed 58,000 miles on one 6-month deployment. That is a couple of times around the world on one deployment. So folks have been working.

RETENTION

The bottom line is: how are the people surviving this pace of operations and the challenges that we have to face? The answer is that by the measures we have—who stays, who goes—retention is up, but ever so slightly, and still well short of where it ought to be. Enlisted retention has improved; congressional initiatives have helped us. Officer retention is not getting any worse, but we are still at about a 40 to 45 percent level. I think the highest we have seen is 48 percent, when the requirement in the submarine business is 55 percent.

The surface community is a special problem, and the Chief of Naval Operations has a number of initiatives underway. You will hear more about that from the Navy. The very small number of nuclear surface ships we have make that a very tight little overworked enclave. We are having trouble keeping people in it. I finish this recount with retention because that is where I am going to spend most of my time talking later. I think there are some things you should understand about the way we do business in the personnel and training area.

SOVIET DEVELOPMENTS

The Soviets have also been busy. Since we started design of the new submarine the Soviets have launched six new designs of their own. Six. We haven't even finished the design of our new one. The

latest of the six just appeared, *Akula*. That is a poor picture, taken from a long way off, of the submarine they call the *Akula*. They have built so many, the alphabet wouldn't work anymore.

Remember, we called them *Alfa* and all the other letters. Gone. Used up the alphabet. Now this one is called *Akula*, the Russian name for shark. It doesn't look very different but the interesting thing about it is that it is very large, [deleted].

PERSONNEL CHARACTERISTICS

I told you last year these are the submarine characteristics we have to have if we are going to do the business set out for us. I said if we don't build submarines that can operate alone and unsupported and stay on the station for an extended period of time in the face of heavy opposition and survive, we have no business building them.

Submarines that can't do that are a waste of taxpayers' money. We build submarines that can do it. But what I skipped when I discussed this last year is that people are what make these ships work. We have to give them the hardware, but it takes an extraordinary group of people, extremely well trained. I like to say—Marines will probably argue with me, but I like to say and I believe it—that the training and qualification standards we demand of these people are the toughest in any service in any country in the world. And we have to keep the standards that way because we have a special responsibility.

We operate power reactors in your district, Mr. Stratton, as you well know, and in downtown New London, and occasionally out in the Chesapeake Bay, Mrs. Holt. And we are going to send these guys out in the deep ocean carrying a terrible personal responsibility. So it demands an awful lot of the individual.

This is the kind of guy we are looking for. This is the kind of guy we have. Integrity, stamina, gumption and independence. We develop the professional competence. I have noted independence because that is another important thing. What are we doing? We are asking a young man to learn rigorously how we do business, force him to live with the requirement for absolute verbatim compliance, and yet remain a thinking man with a lot of initiative.

That is hard. It is particularly important in the young officers and commanding officers because in the final analysis, independent is the way they are going to have to operate.

I would just like to discuss a few of these guys because I think that will bring it home to you.

NAVAL NUCLEAR PERSONNEL

Mr. Stratton, Petty Officer Paul Lattimore is a reactor operator on the U.S.S. *Henry M. Jackson*—he is a first class petty officer. Moved right up the line very rapidly. That guy spends about 60 percent of his time away from home and he works like hell. He makes a living wage, but it takes more than that for him to stay around.

Mr. BADHAM. How long has he been in the Navy?

Admiral MCKEE. He has been in the Navy about 6 years.

Another of your guys is Commander Pat Dunne, executive officer of the U.S.S. *Baton Rouge*. That guy is a tremendously marketable commodity because he has a fine professional education in engineering. Better than that, he knows how to make decisions because he has to make them independently. He carries an extraordinary responsibility. He is about 30 years old, something like that, qualified for command of submarines, not quite old enough to get there. He is an early selectee. That means he is so good he got promoted ahead of his contemporaries, and that is why he is a commander.

Here are a couple of your men, Mrs. Holt. Petty Officer Peter Harsh, an engineering laboratory technician. His principal responsibility is the radiological health of the crew. He is a marketable commodity. Because of the difficulties in the commercial power industry, the technician business has really blossomed. He can make three times what he makes in the Navy if he walked out the door tomorrow, going to work for one of the firms that supplies this kind of technician to various commercial power activities.

Another of your guys is the engineer officer on U.S.S. *Phoenix*, Lt. Cdr. Randy Zeller. He is a lieutenant commander, but a spot-promoted lieutenant commander. You understand what I mean by spot promoted. This is a guy who is good enough, has been examined, qualified to serve in our business. He goes to the billet as a lieutenant and we make him a lieutenant commander, even ahead of the selection process, because we have the confidence that the selection process is going to come back and get that guy. Again, a tremendous personal responsibility.

I have one of Congressman Mavroules' men; I guess the Congressman is not here this morning. This is one of his guys, Dan Turcotte, first class petty officer, an electronic technician.

Mrs. BYRON. We will tell him.

Admiral MCKEE. OK.

This is the same kind of guy as Lattimore, but he is an instructor at a prototype, one of the people that has to establish the ground-level fundamental understanding in the students before they go out in the fleet. I will talk more about that.

Mrs. Lloyd, I have a couple of your folks here too.

Petty Officer Steve Hill is an engineering watch supervisor. I will explain what that means in terms of plant operations. A first class petty officer, he is about 25 years old. He is on the U.S.S. *Ohio*, a Trident submarine.

The other one is Rich Snead.

He is the engineering officer on the U.S.S. *Cincinnati*, a lieutenant commander. He's got a different situation on an attack submarine than these guys do on the Trident and Polaris submarines. One of the nice things about serving in the ballistic missile submarines is when you go away and come back you give the submarine to somebody else and you go home. He can't do that. He comes back from 7 months in the Indian Ocean, goes down to the pier the next day and that boat is right there waiting for him to start the maintenance program.

He works hard, an extraordinary young man. This is one of Senator Warner's folks, Commander Mike McHugh.

He is the skipper of U.S.S. *Haddock*. The ship is in overhaul, which is the dirtiest, most difficult job you get as a commanding

officer, taking that ship through an industrial facility, bringing it out in one piece and delivering it on time. The ship he commands is an older submarine, the same kind I commanded. But he and guys like him are keeping those in first-line posture. [Deleted.]

Let me put in perspective what these folks do. To do that, I have to go over here to this board, and I hope you will be able to see it all right.

Mrs. BYRON. Don't I have anybody on the submarines?

Admiral MCKEE. You do, Ma'am. You have a whole batch. But that is all I brought with me.

Mrs. BYRON. We don't like water? Landlubbers.

Admiral MCKEE. I have to tell you honestly, what we did was make a list of everybody in the committee. Then I went and got a guy from everybody's district. Then it occurred to me I would bore the ears off every one of you and you would think I was trying to set you up. But I will send you pictures of the guys.

Mrs. BYRON. I know where my guys are. I just wanted to make sure you knew.

Admiral MCKEE. We know.

NAVAL NUCLEAR TRAINING

Those are guys serving on the ships. They have gone through a very vigorous training program that establishes a foundation of competence.

We run the Nuclear Power School in Florida. We own it. These are numbers you should remember. The enlisted curriculum demands 690 classroom hours in 6 months. That is the equivalent of 3 semesters of college education in 6 months for a high school graduate. It's tough. Between this and the practical training, our attrition among enlisted men is somewhere of the order of 25 to 50 percent. Twenty-five to 50 percent.

The officer curriclum is different. The number of hours are about the same. Again, three semesters worth, but most of this is at the graduate level. They get no graduate-level credit for doing this. At one time in the program there was an effort to come up with some sort of a degree for this work. We decided we couldn't do that because if we did other folks would get in and tell us what to teach to satisfy degree requirements rather than our specific requirements.

Mr. STRATTON. Is this the training the officers get up at Kesselring site?

Admiral MCKEE. No, sir. This is what they get at the Nuclear Power School in Orlando. I will talk about the Kesselring site and the other prototypes in a moment. That is the fundamental——

Mrs. HOLT. How did the quality of people—I remember, I guess it was 4 years ago when you testified before the committee, one of your real concerns was the quality of people you were getting. Has that improved?

Admiral MCKEE. Ma'am, the quality is good but the attrition hasn't changed much. The better they do, the harder we lean on them.

Mrs. HOLT. Well, once aboard a submarine, I had the feeling this was the last absolute dedication you see anywhere in the world.

These guys are really dedicated. I guess that makes it tougher than anything we try to recruit.

Admiral McKee. Well, they are. It's a great pleasure to serve with them. Old admirals like to tell sea stories. In the submarine I commanded, 85 percent of the guys that were there when I went aboard were still there when I left. Most of them on their own decided to learn how to do more than they really needed to learn how to do. We were out doing a very difficult, demanding operation. I looked down at the fire control system, and there is a reactor technician sitting down there with a fire controlman. I said, "What are you doing up here? You belong in the other end of the submarine."

He said, "Captain, you got big problems up here, you ain't got enough guys to man this equipment, and I haven't got enough to do back there this week, so I thought I would come up and get qualified to run a fire control system." The photographer that did some of the work you saw last year was another guy who did it in his spare time. The best cook in the ship was a chief fire controlman. It's a strange situation. That doesn't say much for my other cooks. But everybody really reaches a little farther than they have to. What you try to do, of course, is create an environment in which it's stylish to do that.

I have talked about theoretical training, where we establish a fundamental understanding of the basic physical relationships involved. But the next step is to teach them how to run a real reactor plant.

NAVAL REACTOR CHARACTERISTICS

Now, this is where we do the work up at the Kesselring site, Mr. Chairman, this is a model of the engineering plant in the 688 submarine, but it's representative of what is at the prototypes. It's kind of hard for you to see. So while I step around and tell you what is there, I will show a real place that goes with the model.

The point I would like to make with this is that operation of a reactor plant is a big team effort. The sort of conventional wisdom prompted by those familiar with nuclear power in the commercial industry is to think: Well, where is the reactor control room? Because that is where it all happens. At Three Mile Island everybody was in the reactor control room. There was one guy out on the floor.

We have a reactor control room. That is this place. We call it the maneuvering room. In it we have an engineering officer of the watch. That is a young officer. A reactor operator, the guy who has the responsibility for operating the reactor itself, electrical operator, and the throttleman, the guy that controls the throttle.

Before I go on with that, let me put something in perspective for you because I think it is important. You have all read about nuclear power and how it works. What you have is a core, with control rods in it. Everybody sort of knows that as you withdraw the control rods, the reactor goes critical. The more you pull them, the higher the power level gets. If you want to shut it down, you do something to force the control rods back in. That is a basic way to look at it, but it's wrong. It's wrong in the light of the way we do

business. It fits the mold for commerical nuclear power; that is sort of the way they do it. But not us. Our plants are built to be inherently stable and respond to demand with minimum requirements on the operation of the control rods themselves. So in our plants the control of reactivity, that is, the things that make the power change, is managed by more than just moving control rods.

Try to remember this because I will show you what that means in a minute.

The reactor heats water and the steam goes back to the engine. The more steam you ask for, the more power you get. It works that way because of a thing called negative temperature coefficient, so that if anybody in the engine room does something to demand more steam the reactor will give you more power. If battle damage causes a steam leak and we don't control it quickly, we can have a major reactivity insertion, a big power surge, without anyone touching anything.

Anything that tends to cool a reactor makes it provide more power. The steam turns back into water as it goes through the turbine and it comes back into the reactor core. It's cold water. Cold water, down around [deleted] degrees compared to about [deleted] degrees in here. If water is added rapidly, too rapidly, the same thing will happen, the guy who is controlling the flow of water back to the steam generators can cause a major surge in power.

[Deleted.]. If the pump stops and you start it again under the wrong conditions, you will send a slug of cold water into that core and get a serious surge in power.

Think about that. There are a whole bunch of different ways that we can increase power. It's not just one guy sitting over there at that panel running control rods in and out.

And that is the end of the filibuster and schoolroom lesson.

Mr. STRATTON. Isn't the throttle actually a wheel?

Admiral MCKEE. Yes, sir. That is the one you qualified on.

Mr. STRATTON. That is right. I got a certificate from Admiral Rickover.

Admiral MCKEE. Yes, sir, that is right, in the S8G plant. When you opened that throttle, you were controlling the power level of the reactor. You notice the reactor operator didn't do anything but stand there with his hands folded.

Mr. STRATTON. That is what I thought. You sort of suggested you had four different people, one controlling the steam and one the water.

TRAINING ON OPERATING REACTORS

Admiral MCKEE. Yes, sir. Each one has a different responsibility. I have to be careful I am not putting this too much in a negative sense. What I have told you is that all kinds of people have to do it right to make sure the ship performs the way it is supposed to. The guys who are controlling the reactivity are not just living in that little room up there. It is one guy in that room, the throttleman, another guy right here who does maintenance on the rod control system, who, if he makes a mistake, can cause inadvertent rod motion, the feed station watch—he is the guy that gets the water back in, the engineroom upper level watch, who controls the

turbine generators which provide the power for the pumps, and so on and so on. Also you have to remember, this is a submarine. It is a warship. You have to have people in various places in the compartment to deal with casualties. A leak in one of the small pipes in the seawater system will fill this compartment with water in less than 1 minute, and the ship will sink. So you haven't got time to have two or three guys standing up here in maneuvering, waiting to hear water running somewhere and to go down to see what is going on.

In a submarine you generally have on the order of [deleted] seconds to establish a stable condition. After that it unwinds pretty badly. That is what we do in the training program.

This is a real upper-level engineroom watch. I want you to see the complexity of the thing.

That is an engineroom supervisor.

This is an engineering laboratory technician. [Deleted.]

The requirements of the program are based on careful training. That is nothing I invented, as you well know. Admiral Rickover came up with it. We demand verbatim compliance. But it's more complicated than that. You can't just give a guy a list of things to do and qualify him as if he can go Easter-egg hunt his way through all those things and get them done. Verbatim compliance, by our definition, is compliance with an understanding of the fundamental principles. They must develop and demonstrate their ability to operate a real reactor at a prototype site such as the Kesselring site. This is why we are going with the moored training ship, trying to save a little money, as a matter of fact, but still retaining the ability to train on real reactor plants.

You recall, I may have told you about this last year, about how the *Nautilus* prototype has been running over 30 years now. It was built to an earlier standard and it has gotten to the point where trying to keep it running past about 35 years is not going to be very cost effective. We estimate we would have to spend something on the order of $500 million to restore it. So what we want to do is develop the capability to train operators on a previously commissioned submarine.

We are also doing a little bit of work with simulators, Mr. Stratton. But as you and I have talked, that is a fairly tender subject in our business. There are a lot of folks who say, "Look, McKee, you are in the dark ages. The commercial power industry has simulators. They just put the trainee in a simulator. When he is qualified, they send him to a real plant and he does just fine." We can't play that game. But the important thing for you to carry away is that when you talk about a simulator you are talking about that little box. You can imagine trying to simulate this entire complex.

You could probably do that, if you wanted to spend the money to do it. But the worst thing about it would be when you get through, it wouldn't be real. You would be training people under conditions where if the exercise goes bad they turn the switch, reset the program, and start all over again. A guy has to grow up learning to live with the consequences of his mistake, and the instructor has to know that as he brings his students along, because the most important product you get from this is a set of instincts. In the final

analysis, it's the instincts that give you the ability to do the right thing in the [deleted] seconds you have.

So we are doing a little bit of work with simulators but it's primarily devoted doing something we cannot do with the prototype plants; that is, take the plant into extremis. We don't want to do that in New York State. We don't want to do it in Idaho or in Charleston, SC or San Diego or any of those other places. So we need a device that will show us the relationships between temperature, pressure, flow and power level when the reactor has sustained battle damage and is in extremis, so people will understand what happens.

But that is as far as we want it to go. It should be a graduate exercise, not the fundamental training.

HEADQUARTERS PERSONNEL

I have talked about the operating people almost exclusively. Let me finish by talking about another set of people that are terribly important. They are the headquarters folks. As you know, the sine qua non for our operation is central direction, central responsibility, central accountability. The guys in my headquarters, 200 and some-odd folks, have been there a long time. They are awfully good. They design the reactor plants. But in connection with people, look at what else they have to do in their spare time. They approve curriculum at the Nuclear Power School. They establish qualification standards. This lists the subjects one guy has to become conversant in to qualify as engineering officer of the watch. That is approved by my headquarters. We select the officers just like Admiral Rickover always did. The interviews are still there—in a somewhat different character, but they are still there. We have to support the operating ships and we examine them and examine them and requalify them over and over again.

My headquarters people are critically important. Those guys are civil service and the instabilities in that business worry me to death. Any of them could do so much better outside the Government. They know their worth. The bottom line——

OFFICER ACCESSIONS

Mr. SKELTON. Mr. Chairman, may I ask a question at this point?

Mr. STRATTON. Yes.

Mr. SKELTON. There for a while the officer candidates were being chosen whether they wanted to come there or not; is that not correct?

Admiral MCKEE. That was for 1 or 2 years.

Mr. SKELTON. That is not the case now?

Admiral MCKEE. No, sir; all volunteers.

Mr. SKELTON. Are you getting the cream of the crop?

Admiral MCKEE. We are getting super young folks.

Mr. SKELTON. To answer my question, Admiral, are you getting the cream of the crop?

Admiral MCKEE. Yes, sir.

Mr. SKELTON. The top 10 out of Annapolis?

Admiral MCKEE. No; we got No. 1 and No. 2. I think last year from the Naval Academy we had 340 some-odd volunteers.

Mrs. BYRON. No. 1 was a female last year.

Mr. SKELTON. Is that right?

Admiral MCKEE. I beg your pardon?

Mrs. BYRON. No. 1 was a female. You couldn't have gotten her.

Admiral MCKEE. No, ma'am; I am talking about this year's crop. You are right about last year's graduates. I am talking about the ones I just finished interviewing.

Mr. SKELTON. What percentage of them come from Annapolis, what percentage from your other, ROTC, et cetera?

Admiral MCKEE. We shoot for about 30 percent from the Naval Academy, 30 percent from NROTC and the rest through the officer candidate program. Those are the guys that come from college.

Mr. SKELTON. Do you have direct appointments by nuclear graduates, as you used to?

Admiral MCKEE. You mean for the operating folks?

Mr. SKELTON. Yes.

Admiral MCKEE. We have a program that amounts to a direct appointment. A youngster who is in college in his third or fourth year and wants to get into our program can submit an application. If his performance is good enough, we will interview him.

Mr. SKELTON. But he has to be in a scientific field, nuclear or whatever?

Admiral MCKEE. No, sir; he does not have to be, but in general those guys are. What we demand is a minimum of 2 years of physics and four semesters of math through differential equations.

Mr. SKELTON. I doubt if anyone on the committee would qualify. I know I wouldn't. Thank you.

Admiral MCKEE. Yes, sir; but it's not easy. Right now where are we? We are at 85 percent of our quota for this year. We are pretty near the end of those that we will be interviewing.

FLEET OPERATIONS

When you get all through you say: What do you ask these guys to do? Here it is. Here is an aircraft getting ready to launch into that terrible weather from the carrier. One of our carriers just put in 9 months in the Indian Ocean and didn't touch port.

This one is particularly interesting. It is a submarine that just surfaced at the North Pole. He broke through about 4 to 6 feet of ice in the wintertime. It's lonely up there. And it's a hell of a long way to the hardware store. We keep asking people to do that, and they like to do it and they are awfully good at it. But let me tell you that is one of the most difficult and dangerous things in the world. Where do you get people to carry that kind of responsibility?

Again, they operate a reactor in a populated area, take it to sea and, in the case of the missile submariners, carry a terrible personal responsibility.

Here is a submarine covered with ice in New London. They say get underway. You go.

This is a surface ship undergoing shock tests. We set off [deleted] tons of TNT alongside a nuclear-powered cruiser to prove that it's going to be able to withstand the shock of battle. But the final shock, the one I want you to remember when you walk away from here, is this one.

One of those days somebody may have to do that. You have to ask yourself what kind of folks you want manning that submarine, what kind of commanding officer, what kind of missile officer, what kind of fire control chief you want carrying that responsibility. Because he's out there alone. He must respond. He knows better than anybody else the consequences of what he will have to do—personally, nationally, and internationally. That is a heavy weight for a young captain, a young chief petty officer. Think about that. The minimum we can do is make sure they have the tools to do the job and an environment in which to do it successfully.

Mr. Chairman, that is all I had in my prepared talk.

BUDGET OUTLINE

Mr. STRATTON. Do you want to outline what is in your budget for this year so that we get an idea of what we need to provide to you so that you can continue to attract the people that you have outlined for us?

Admiral MCKEE. Yes, sir; we have a total budget this year of $569 million, of which $66 million is for what we call plant development. That is for the development of components. We are asking for $261 million for reactor development, which is the development of reactors and research and development in connection with reactor related areas—that is, metallurgy, radiation exposure, that kind of thing. And $150 million for reactor operations and evaluation. A good portion of that goes to maintain these prototypes.

One of our biggest tasks in the next 10 years is a great deal of major work to be sure we are able to operate those prototypes well into the next century. This is a busy chart. All you want to do is get an impression from it.

That is the work schedule we must meet to maintain all these land-based prototype reactor plants. You can see we virtually have to refuel them all in the next decade. We are going to retire the SIW plant as the moored training ship comes on line. We also have to do routine maintenance on all the plants all the way through—a very tough, not inexpensive program, but critically important if we are going to be able to make these plants carry both their training and research and development responsibilities.

Mr. SKELTON. I don't want to interrupt but I have a question when you are through.

Admiral MCKEE. I will just finish the tally. We are also asking for $30 million in capital equipment and $50 million in construction funds.

ADEQUACY OF COMPETITION

Mr. STRATTON. Mrs. Lloyd wants to ask a question.

Mrs. LLOYD. Thank you very much, Mr. Chairman.

Admiral McKee, it's certainly good to see you here today. I read your statement about 9 o'clock last night and feel that you have made a great deal of accomplishments. You had a great deal to say about the sterling quality of the people, the nuclear trained submarine officer and commading officers and the operational people. But how about our contractors/suppliers? You do depend on them for

the new SSN-21 and the reactor for it. And we all know what it takes to develop new technology, and it is competition. Do you feel you are doing all you can to foster competition in the reactor program?

Admiral McKee. Well, Mrs. Lloyd, we have an industrial base amounting to approximately 800 contractors operating under four prime contractors: The Bettis Atomic Power Laboratory, Knolls Atomic Power Laboratory, the Plant Apparatus Division, and we have the Machinery Apparatus Operation——

The laboratories are research and development laboratories. The laboratory has the lead responsibility, for example, of designing the S6W reactor plant for the new submarine.

Mrs. Lloyd. Who is that?

Admiral McKee. Bettis Laboratory.

Mrs. Lloyd. Bettis?

Admiral McKee. Yes ma'am. The procurement prime contractors are the Westinghouse plant apparatus division, and the machinery apparatus operation, which is General Electric. Those organizations are the principal procurement agencies for my heavy equipment, my electronic equipment, and everything else I use with the exception of reactor cores, which are contracted directly between the core manufacturers, two of those, and my field offices.

Mrs. Lloyd. You have only two contractors for the reactor vessels, isn't that correct, in B&W and Precision Company? Is that correct?

Admiral McKee. The two heavy equipment manufacturers we use right now are Babcock & Wilcox in Barberton, Ohio, and Precision Components Corporation in Pennsylvania, formerly an Allis Chalmers operation.

Mrs. Lloyd. Well, are you going to need a quantum leap for the new SSN-21, as "Seapower" magazine referred to and said this was a quantum leap? How are you going to get that for the new reactor without more competition? The DOD has put the SSN-21 on a fast track and omitted many program review documents, according to the Inspector General report. The DOD Inspector General Report of September 3rd said that although the Milestone 1 review was scheduled for December 1983, the Navy advised DSARC they could not prepare for formal review at that time. The DSARC meeting had to be re-scheduled as a program review rather than formal Milestone 1 review. But even then, the DSARC requirement document, such as the concept paper and master plan, were still not available as of October 1984. Then the Navy documents that were submitted at the December 1983 program review meeting were incomplete; according to the Inspector General's report, out of the 15 areas required to adequately address the problem, only four areas were partially covered and seven were not even addressed.

Then the report goes on to say a milestone decision was made for a major acquisition program without a complete package or complete documentation.

Further, DOD Directive 5001 requires that the decision memorandum be issued within 3 weeks of a DSARC meeting. In the case of the SSN-21, the decision memo was issued in June 1984, 6 months after the meeting.

Well, I am asking you, is this fast track necessary? Now, I don't agree with the program's critics that say we should not go ahead with the new sub. However, I am not convinced that, as it is presently conceived, that this is a quantum leap in technology that is going to meet the Russian threat beyond 2010. I am also concerned, as any defense proponent on the committee, about airing sensitive information. But I am not comfortable with the rubberstamp and the skids are greased approach to the 21 program. I am happy that Secretary Lehman has agreed to some competition. But that is only between the two shipyards. I urge you to do all you can to meet the Russian threat, by carrying out the integrated research and development. I really think it is necessary.

I want to say right now that I first approached this from a very parochial standpoint because there is a very important industrial player in my district, Combustion Engineering. I don't make any secret of that. But my concerns now go beyond this because I do think this program needs more scrutiny and I intend to look at this issue further, sir.

I mean, really, what kind of language do you need to bring competition into this program?

INDUSTRIAL BASE

Admiral McKee. Well, Mrs. Lloyd, you asked what we need to bring competition into the program. Let me step back just a moment, first of all, and say that the question you asked, as you said, started with a fairly parochial view. And the question has been raised for a number of years. In 1982 the question came up, as soon as I took over my job. And the focus was always the same but the approach was different. One question came through OMB but it's difficult to trace the origins. The concern was: Admiral, do you have an adequate industrial base? In particular, we are concerned, can you sustain your industrial base with the commercial power industry going down the drain? This is the kind of thing that prompted that question.

That is the situation. The Navy reactor business was large in the beginning and then got smaller. The commercial nuclear power industry blossomed until the mid-1970's, when it started to decline. These are actually negative orders. By that I mean, orders for civilian reactors which were canceled. So, folks who were doing our business back here lost interest when the civilian business was good. And in fact Combustion Engineering repeatedly refused naval reactors business in this period even though we asked them to do it. They repeatedly refused the business. Until now we are in the situation here. So our marketplace is affected by two things. It's affected by the civilian——

Mrs. Lloyd. Admiral McKee, that was 20 years ago.

Admiral McKee. Please let me continue and try to bring you into the present time. It really wasn't 20 years ago because it was the early 1970's the last time we asked Combustion Engineering to help us, and they refused.

Now we are also influenced by the shipbuilding program. As you can see, the shipbuilding program fluctuates all over the place. Here is a heavy building program. This was the period of time

when we decided we better get busy and get some more people in the game, particularly in heavy equipment. This is the time we asked Combustion Engineering to come back in and they declined. We went and got two more heavy equipment manufacturers. Of course, what happened was that the business went down and two of those heavy equipment manufacturers failed. In one case we went through an 8-year, $100 million lawsuit as a result of having brought somebody on board. So what we try to do is maintain competition and maintain the business base.

There is a requirement to do both. We can't simply play the winner-take-all game, because that gets you into underbidding. In fact, some of the bidding is business sensitive, so I won't give you numbers, but some of the bidding that went on for heavy equipment this year is considerably below the certified cost from the manufacturer. That says both guys are already bidding low. When they start bidding too low, we worry about running into the same problems we had with our submarines in the late seventies. So we maintain competition and it works.

There is the track record, Mrs. Lloyd, in heavy equipment prices in the years since I have been in the job. Admittedly, inflation has been low, but look at what the unit prices in my heavy equipment are doing right now. They are going down. That attests to the adequacy of the competition in our heavy equipment. The question then becomes, can you afford to expand the industrial base to include a third supplier? And the answer is that we really can't.

If you look at the capacity of the two vendors that are doing my business right now, this is the business we have to do. This is the capacity of the two vendors that are already doing the business. The only place we had more business than capacity was in this period, because of the two carriers authorized by Congress.

Mrs. LLOYD. Admiral, why is it Combustion is not allowed to bid when Babock & Wilcox has a backlog of over $1 billion of contracts from you, then?

Admiral MCKEE. Mrs. Lloyd, we will always have a backlog at both manufacturers, because it takes me anywhere from 3 to 5 years to build a component. Combustion Engineering also has a backlog. We have given Combustion Engineering opportunities to bid.

Mrs. LLOYD. Look, whether its Combustion or another contractor, I just want another contractor. If we are going to have the best submarine, I don't want another 688. I want the best submarine. I am not your adversary, but I think if we are having the same people, and go the same route we have always gone, if we are going to have a new and better submarine then I think we need some more competitive bidding in it. Westinghouse awards jobs to Precision Materials. When they can't do all the work they send the subcontracting back to Westinghouse. And I just don't think this is the way to do business for the best product.

CONTROL OF TECHNICAL DATA

Admiral MCKEE. When you talk about the best way to do business, you are talking about design now?

Mrs. LLOYD. That is right.

Admiral McKee. The best way to do design in our business is to take the best guy we have and give him the lead. Then we control the design to our detailed specifications right down the line. This is the way the program has done business for a number of years, and we proved that it works. We are then able to have a standard Government-owned design. There is no proprietary interest involved. And as you well know, there are a number of things being offered up in various areas of the Congress to require us to give up patents and rights that we prefer not to lose. We maintain the rights so that when we go to series production we own the design. We can have the manufacturers who are going to bid on it warrant that design, and then build to our specifications.

DESIGN STANDARDIZATION

We have from time to time done what you suggest. Years ago there were four different companies building steam generators. Not Combustion Engineering in those years—they didn't want the job. But four different companies. And there were about 12 different designs of steam generators. As I look at my operating fleet right now, I can see a terrible penalty we are paying in terms of increased maintenance for some of those units because we did not standardize the design in those days. We were building 12 boats a year. We really didn't have the manpower to do it. But the business is low now, four boats a year. This is also the lesson, Mrs. Lloyd, that the nuclear-power industry is learning a very difficult way, that standardization is the way to go to ensure safe operations.

Mrs. Lloyd. Admiral McKee, I am a big advocate of standardized design. I am a big supporter of it. As you well know, I am cosponsoring legislation for standardized design. That is not what we are talking about.

Admiral McKee. Yes, ma'am, it is, because we have to do the design, and we have to control the design.

For example, part of the design of this ship, of this equipment, is going to involve an awful lot of noise work, because the noise levels which we are going to have to achieve in the submarine are [deleted] better than anything we have ever done before. That means that not only do we design the component on paper, but we have to build test components and put them in a new facility.

We are going to take each component as part of the design process. Iterate. Iterate into this test device, back out again. Feed information back into the production units for the first ship.

We won't have a prototype of the new submarine propulsion plant. We are going to put a core in an existing prototype, and we are going to have to prototype certain elements and do these tests and iterate the design back again.

We have never done this before. That is part of the design process.

Now, when you look that design process over, it is time-consuming. This is an absolute requirement.

I will give you an example of why we need to do it. This is a piece of equipment from a reactor core. [Deleted.] So we have to do this work in the design process. That means that the best thing to

do is to set up a very rigorous integrated design schedule that doesn't belong to any particular manufacturer. It belongs to us, and the design is carried through to standardization. We then complete it as we do our other business.

BUDGET CHANGE

Mrs. HOLT. Mr. Chairman.

Mr. STRATTON. Mrs. Holt.

Mrs. HOLT. Thank you, Mr. Chairman.

Admiral, thank you very much for being here this morning. In looking at your budget request of $569 million, you say in your statement here that it is a $72.1-million increase over your fiscal year 1985 request. We are going to have to be looking very, very closely at our priorities, and you say that this increase is due primarily to escalation. Then, of course, increased prototype servicing effort, as the overhaul and refueling activity enters its busiest phase.

How are we going to justify that $72.1 million? You have got a good statement here, but I would like to hear your comments on it.

Admiral MCKEE. Well, it is hard in this budget climate. The principal allocation of those resources is for the things you cited, to cover escalation, to cover prototype servicing which we have to do, and part of the work on the Advanced Fleet Reactor for the new submarine.

As I also said in my statement, I would ask you to note that at a time when everybody else's budget was going up last yer, mine stayed flat, so I would like to take a little credit for holding the line at that time.

There is a 14 percent increase——

Mrs. HOLT. We don't give credit around here for that.

Admiral MCKEE. If we are unable to get what we request, then, because we are a cradle-to-grave operation, as you well know, our principal responsibility is to keep the fleet operating successfully, and to train people to operate. That says that off the top comes what it takes to support the operating fleet and what it takes to do the prototype overhaul and maintenance.

What is left would go into new development. It would seriously injure our ability to maintain the schedule of the new submarine.

Mrs. HOLT. Thank you.

Mr. STRATTON. Mr. Skelton.

Mr. SKELTON. Admiral, I got here a couple minuters late, and for which I apologize. Be that as it may, I am still having a difficult time understanding your initial testimony and your request, and the connection thereto. It seems to me that your testimony should have been before the Personnel Subcommittee. I am having a difficult time tying that into your request which I have in front of me.

I would like to ask you about that, then I would like to ask you about your request, please. Did I miss something, Admiral?

Admiral MCKEE. No, sir. Let me put that into perspective for you, and that is, as Mrs. Holt just asked, why the increase this year, and why our budget is growing. One of the principal reasons our budget is growing is because we have to do all that work on the old prototypes. Remember that busy schedule I showed you? We have

to refuel virtually all of the prototypes in the next 10 years. If we are unable to keep them going, then it is going to effect a fundamental change in the standards of training and qualification that makes these folks able to do what they are able to do. That is the tie in.

Mr. SKELTON. That somewhat answers my second question. Let me ask it anyway.

In 1984, you got $197 million. In 1983, $213 million. For 1985, evidently you asked for the same thing, $213 million, but this time you are going up a considerable amount, mostly in the reactor development operating expenses, construction, so on area.

Admiral MCKEE. I think those are numbers of people; is that not correct?

Mr. SKELTON. No; it doesn't look like it. You tell me why you go up in 1986, from 1985 to 1986, of $277 million to $311 million, in reactor development.

My question——

Admiral MCKEE. I am trying to find the numbers.

Mr. SKELTON. All right.

My bottom line question is, Admiral, what if you got the same amount as you did last year. I am sorry. I was using the wrong figure there earlier. It was $496 million, now it is $569 million. I apologize.

What happens if you got the $496 million? What would you have to do there? What would be your recommendations if you were given the bottom line, had your "druthers" on spending $496 million instead of $569 million?

Admiral MCKEE. We would have to virtually terminate all advanced work, because we would have to spend most of what we had to carry out our responsibilities in support of the operating ships.

Mr. SKELTON. That answers my question. Thank you.

DANGERS OF OVEREXTENDING VENDOR BASE

Mr. STRATTON. Mr. Dyson.

Mr. DYSON. Thank you.

Admiral, in the course of your response to Mrs. Lloyd's question, you mentioned something about an 8-year, $100 million lawsuit that came about as a result of someone, I think her quote was, someone you brought on board. That is the first time I have heard that.

Can you supply any additional information on that?

Admiral MCKEE. Well, it was a long, tedious process.

Mr. DYSON. I don't want to go through the whole trial. A $100 million lawsuit, that almost rivals General Westmoreland's.

Admiral MCKEE. The name of the company was Curtiss Wright. They were brought into the heavy equipment business toward the end of the sixties, early seventies. And at the time, remember, I showed you that the shipbuilding program looked like things were going to expand. They were involved in some of the Trident work, and they were just losing money. They were unable to operate in that environment.

Again, it was a case of expanding the industrial base beyond the requirement for the industrial base. They just didn't do enough

business. So they decided to get out after losing money on most of what they built. Then they filed suit against the government's prime contractor, a fairly complex suit, to recover their losses in that effort.

Mr. STRATTON. What is this company, Admiral?

Admiral MCKEE. Curtiss Wright.

Mr. STRATTON. Curtiss Wright.

Admiral MCKEE. Yes, sir; they finally settled 2 years ago, with no increase in the price.

We got a favorable settlement out of it. It was 8 bitter years tying up an awful——

Mr. DYSON. What do you mean by a favorable settlement?

Admiral MCKEE. We didn't pay them $100 million.

Mr. DYSON. Did you pay them all that overage for the period?

Admiral MCKEE. No, sir; we did not. We settled on the order of $10 million. That was to cover actual costs. In other words, one of the things we did was to try to separate what they claimed and what was actual cost incurred properly in the execution of the contract, and we paid them for their actual costs.

Mr. DYSON. Unless I am misreading this, are you telling me you basically brought this contractor on, the contractor was not able to meet the requirements, and found that out midway through the process, decided to get out because it was costing so much, tried to recoup that through the suit?

Admiral MCKEE. It wasn't a case of not being able to meet the requirements. It was a case of being unable to make a profit doing that business, and he just wanted to get out of it. He sustained some losses in the process of developing the capability and in production, and he attempted to recover those in the courts.

Mr. DYSON. Thank you.

Admiral MCKEE. You know, that experience is very much on our minds as we look at our industrial base. That is why we want to maintain enough people in the business to do our business and to keep competition, but not go beyond that to the point where we have that kind of thing happening.

REACTOR CORE LIFE

Mr. STRATTON. Mr. Badham.

Mr. BADHAM. Thank you, Mr. Chairman.

Admiral, a pleasure to have you here.

What is the level of this briefing? Can we talk about anything?

Admiral MCKEE. [Deleted.]

Mr. BADHAM. In the longer life reactor core program, what can you tell us about how you are coming on that?

Admiral MCKEE. The principal element of the long-life reactor core program is something we call the modified fuel process. [Deleted.]

We have been working on that for about 10 years, [deleted] but that will not be a super long-life core. What we have to do is develop the manufacturing technology and the prototype experience. Then we will take the next step, [deleted].

The problem, however, Mr. Badham, with the life of the ship core is that folks keep changing the life of the ship. When we start-

ed this, the life of the ship was 20 years. Now it is 30, and folks are talking about 40 years. 40 just may be impractical. We are looking at that very carefully.

It is good to build a core that will ensure us we will only have to refuel one time during the life of the ship, but we wouldn't want to get in a situation where we carry the ship through three-quarters of its life, then refuel and have a lot of fuel left over.

Mr. BADHAM. So that is really where you are now. You are looking at a time study situation where you would refuel at about [deleted].

Admiral MCKEE. [Deleted.]

Mr. BADHAM. Yes.

Admiral MCKEE. We believe we can go beyond that. The question is, is it cost effective to that?

Mr. BADHAM. Right.

Admiral MCKEE. Yes, sir.

Mr. BADHAM. Because if you, even on a 30-year hull, if you had a 20-year reactor, that is more than you need.

Admiral MCKEE. That is right.

Mr. BADHAM. Because you are going to have to refuel it once.

Admiral MCKEE. Yes.

Mr. BADHAM. [Deleted.]

Admiral MCKEE. Yes; we have done what I call heat runs in manufacturing last year where we forced the system to get up and run and produce, and it is working. [Deleted.]

Mr. BADHAM. Thank you.

Admiral MCKEE. Yes, sir.

FUEL MANUFACTURING FACILITY

Mr. STRATTON. Admiral, let me ask a few questions here that to some extent you may have already responded to them. Where do we stand in the development of the new fuel manufacturing facility?

Admiral MCKEE. You are talking about Savannah River. Savannah River is coming along on schedule. Our fiscal year 1986 budget has $11 million in it for this work. That is the last year of funding for that program. It should begin to make fuel in 1987.

USE OF SIMULATORS IN TRAINING REACTOR PLANT OPERATORS

Mr. STRATTON. There has been some interest and some pressure about the use of simulators in the nuclear plant. I think you responded more or less to that question, but indicated there are some things you can't exactly handle in a simulator. Could you enlarge on that a little bit?

Admiral MCKEE. Mr. Chairman, we have to train the whole team, and we have to train each guy in an environment where he must take the consequences of what he does. A simulator that would maintain our standards would be a complete simulation of the whole plant; valves, pipes, wires, the whole thing.

There are limited applications for a simulator, as I explained, to teach some of the maneuvering room watches. We can teach what the indications look like when you take the plant into extremis, the thing we can't do in a real plant, but in my judgment, an attempt

to convert from this method of practical training to full simulation would represent a very serious degradation in standards.

Mr. STRATTON. Are simulators used for the conning of a submarine?

Admiral MCKEE. No, sir; there are simulators for limited functions. There is a diving trainer which teaches how to operate the submarine's control surfaces. There is the attack trainer which teaches the fire control party to work. There is a damage control simulator which teaches a guy how to put patches on pipe while standing up to his neck in water, but there is no comprehensive simulator for the forward end that is anything like what would have to be done for the propulsion plant if someone wanted to replace the prototypes.

SSN-21 PROPULSION PLANT

Mr. STRATTON. What improvements are you making to the reactor plant for the SSN-21? I wasn't aware there was an SSN-21, since we are already up past, what is it, 688 or more

Admiral MCKEE. Yes, sir; that is the name of the new attack submarine. Folks gave it that name just to set it apart for the other submarines. The 21 stands for the 21st century. I am sure it will have a conventional number on it.

Mr. STRATTON. The reactor plant, is that unique?

Admiral MCKEE. Yes, sir. [Deleted.]

[Deleted.]

We are also building far greater degrees of resilience into this propulsion plant. [Deleted.]

We also look for the ability through [deleted] and other things we are doing to reach closer to some of the margins to extract an additional measure of performance from the ship.

[Deleted.]

I am sorry Mrs. Lloyd has left. Her concern was would this submarine really represent a major departure from what we have. The answer is yes. [Deleted]

SUBMARINE DISPOSAL

Mr. STRATTON. What is the status of retiring obsolescent submarines? There has been some talk of cutting them up and sending them to the bottom of the sea. I think that has been prohibited by the environmentalists if I am correct, but what other procedures do we have?

Admiral MCKEE. Well, if you recall we went forward with two technical ideas. In either case, you remove the fuel and dispose of that separately. The first method was to take the submarines out and place them on the ocean floor. The other alternative was to remove the reactor compartment from the ship, put it on a barge, float it up river to a disposal site, and bury it in the ground.

The environmental impact statement we published in May 1984 concluded both were technically feasible and both were environmentally acceptable.

The Secretary of the Navy selected the land disposal alternative. So that is the direction in which we are proceeding.

We have 10 decommissioned submarines now, all but one of them sitting out on the West Coast. *Nautilus* is a special case because she is going to be a monument. We have not started the process of cutting out a reactor compartment and taking it up the river. We are in a position where we are ready to start. We plan to put it in the budget and initate disposal actions.

Mr. STRATTON. Is there going to be any problem with regard to where these are buried, similar to the problems we have with waste disposal, with no State wanting to have one of those sites in their borders?

Admiral MCKEE. Well, the plan is to put the initial reactor compartment in the State of Washington because the ships are in storage on the West Coast. I have to tell you honestly not everybody in the State of Washington is awfully enthusiastic about that, but we will put in an established Federal disposal site for low-level radioactive waste. I think we have to be careful we don't confuse the issue of disposal of high-level waste, which is the most volatile issue with regard to waste, and low-level waste, which is what submarine reactor compartment disposal is.

There are sites in other States where we dispose of low-level waste. It becomes a function of adequate geography and the availability of transport to make it practical. The reactor compartment is a big piece to move.

It is practical to carry it up a river. It is not practical to try to take it overland for long distances to a site that is not accessible by water.

SOVIET SUBMARINES

Mr. STRATTON. One final question, Admiral.

[Deleted.] What is the status, present status of our submarines against theirs with respect to speed, noise, and similar matters?

Admiral MCKEE. The biggest difference is in [deleted]. Their production is much higher. They build good submarines, but if we went to war tomorrow, we could whip them. That is it in a nutshell. If you look at this Vu Graph, where this is noise, or detectability, and this speed, in general the faster you go the noisier you get and the more detectable you become.

We have been able to build submarines that remain quiet down to a certain point. Then they begin to get noisier. This is sort of what the profile for the 688 looks like, and the profile for the new submarine will look like that. [Deleted.]

So when I talk about usable tactical speed, that is the point. [Deleted.]

It is this advantage we seek to maintain with the new submarine. [Deleted.]

SUBMARINE CONSTRUCTION

Mrs. BYRON. Mr. Chairman.

Mrs. HOLT. Mr. Chairman.

Mr. STRATTON. Mrs. Byron.

Mrs. BYRON. All right.

I have been quiet all morning. Let me ask you a question. We have spent a lot of time talking about this new submarine that is

kind of getting on paper, but really isn't all the way on paper yet. What type of a timeframe are we talking about development and production model?

Admiral McKee. Well, the timeframe that I am working against is pretty tight.

Mrs. Byron. We are talking about what, two or three 688's a year now?

Admiral McKee. We are talking about 4 a year now.

Mrs. Byron. Four a year?

Admiral McKee. yes, ma'am.

We want money to start long-lead procurement of the heavy components for SSN-21, primarily, my components, in 1987. That means we have to have the design for the heavy components completed by 1987. That is pretty close.

Mrs. Byron. That is breathing down your back.

Admiral McKee. We have to go through all that stuff I showed you earlier when I was responding to Mrs. Lloyd. The new ship is to be authorized in 1989, but there is a difference, Mrs. Byron, in this one.

We have to have the design virtually finished, the detailed design of the submarine, not my part of it, but the whole submarine, has to be virtually finished before we start building it.

This is the first time we have ever done that. We have always sort of designed the submarine as we went along and built it from the outside in. You know, we figure out what it looks like outside. We start building that. Then we go inside and work.

Mrs. Byron. Will you build this from the inside out?

Admiral McKee. Yes, ma'am. We are going to build it in sections. We are doing that today in a jury-rigged sort of way, where we take the old design and convert it. But we will design the submarine so we can build it in sections, then we will finish each piece of the submarine upward of 85 percent. Then we will put them all together and hook it all up. That saves a tremendous amount of time and a tremendous amount of money.

Mrs. Byron. What type of a timeframe are we talking about deployment?

Admiral McKee. The first will go to sea about 1995.

Mrs. Byron. 1995?

Admiral McKee. Yes, ma'am. What that schedule means to me in the reactor plant is that I have to have the core design finished [deleted].

I am into detailed design on the core now. I have to have the reactor plant component design finished in time to go into advanced procurement in 1987. Remember, it takes anywhere from 3 to 5 years to build those big heavy components. The core also takes a long time.

IMPROVEMENTS TO U.S. SUBMARINES

Mrs. Byron. That is what I was basically trying to get down to because we are still bringing in the 688's. Looking at your diagram [deleted].

Admiral McKee. Yes.

Mrs. Byron. So we are talking about really a 10-year timeframe.

Admiral McKee. That is right.

Mrs. Byron. Before we are going [deleted].

Admiral McKee. We are late.

Mrs. Byron. In comparison to what the Russians currently are developing, which is obviously moving toward [deleted].

Admiral McKee. They are working hard at it. They are putting far more effort into it than we are. We are not just leaving the 688 as it is and waiting for the next big step, however.

Mrs. Byron. Are we moving the 688's coming out now?

Admiral McKee. Yes, ma'am, we are doing everything we can [deleted].

Mrs. Byron. But that is no change in the reactor development.

Admiral McKee. No, ma'am.

Mrs. Byron. So your part of the 688 is going to remain the same?

Admiral McKee. No not entirely. The principal improvement [deleted] is in the [deleted] and I do have that responsibility. Some of the DOE money we are spending goes into that, as well as some Navy money.

Mrs. Byron. Thank you, Mr. Chairman.

Mr. Stratton. Mrs. Holt.

Mrs. Holt. [Deleted.]

Admiral McKee. It is hard to say. [Deleted.]

It wasn't just a noise problem. It was a structural problem, but that is a function of how you build it and how you stiffen it. That problem was solved.

The Soviets have worked on that. [Deleted.]

Intuitively, I would say you can't but the Soviets have done a lot of things. I will have to wait and see.

REACTOR COMPONENT COSTS

Mr. Stratton. Mrs. Lloyd asked staff to ask a question she hadn't had time to ask, Admiral. You might want to respond to that.

Dr. Mansfield.

Dr. Mansfield. On the Combustion Engineering end, a competition question. Combustion Engineering bid on S8G steam generators sometime ago. Before their bid, what were you paying B&W for the S8G steam generators?

Admiral McKee. You will recall we were sole-source on the S8G steam generator with Babcock and Wilcox.

Dr. Mansfield. Yes.

Admiral McKee. Even though PCC—well, it was Allis Chalmers then.

Dr. Mansfield. But what was the price, do you remenber?

Admiral McKee. Yes, sir; we were concerned. Allis Chalmers was in financial difficulty about that time. In fact, Combustion Engineering tried unsuccessfully to buy the Allis Chalmers operation and we did not pose any objections to that. Nevertheless, when we saw we were sole-sourcing those steam generators, we went out and paid a premium to Combustion Engineering, qualified them to get into that business.

You asked what has been done. There is the trend of the S8G steam generators. Is that helped by the fact that C.E. is competing?

Yes, of course it is. Of course it is. I think the thing you have to bear in mind, though, is that Combustion Engineering has not been successful in competing for work. The only S8G business they have been able to get has been what we gave them sole-source at a premium to develop their capability. They have only successfully bid on $4 million of competitive procurements.

Dr. MANSFIELD. Nevertheless, the price fell, from what I read, about $12 million to about $9 million.

Admiral MCKEE. That's about right.

Dr. MANSFIELD. At the time you introduced competition between Combustion Engineering and Babcock & Wilcox.

Admiral MCKEE. The 1984 number is 9 and the 1985 is 8.1. Yes, that is the steam generator.

Dr. MANSFIELD. Do you believe that improvement would have taken place without C.E. bidding?

Admiral MCKEE. I would not speculate on whether it would or would not have. Certainly having Combustion Engineering competing helped. Remember, this was the only sole-source situation I had. That is why I went out and brought them in. But I am not sole source in these other areas. The point is not that we are trying to keep Combustion Engineering out of our business. We are just trying to maintain a competitive posture with at least two vendors who are fully employed and employing an adequate amount of their capacity to stay in business.

Dr. MANSFIELD. So C.E.——

Admiral MCKEE. We estimate C.E. will have an opportunity to bid next year on about $30 million worth of business. I would like to give you the history. I think it is important that you understand this factor.

That shows the business opportunities for Combustion Engineering during my tenure in this job, 1982, 1983, 1984, and 1985. Now, the red is what they elected not to bid for. Business offered, no bid. The yellow is business offered upon which they competed unsuccessfully. These two tall stacks of green are business they got, but because we went to them sole source. The only business that this corporation has gotten in these 4 years that I have been in this position, the only business they have won competitively, is this little bit here. And you can see why Mrs. Lloyd is concerned about her constituent, because way back here is all this business they had sole source.

We heard no objection when they got the sole source business here, by the way. Sole source. And then they failed in the competition, or failed to bid and went down to this low level of business. Now I am being asked to make up for that failure. We give them adequate opportunities. We did not interpose any objection when they made an effort to move in and buy out Allis Chalmers' operation. It would have still given us two stable organizations head to head for our equipment.

Does that answer your question?

Mr. STRATTON. I think we have two other sets of witnesses. So I think if there aren't any other questions from members, we should move on.

Thank you very much, Admiral, for your very fine presentation.

APPENDIX A

PREPARED STATEMENT OF ADM. KINNAIRD R. MCKEE

INTRODUCTION

This month marks my third year as Director of the Naval Nuclear Propulsion Program. The time has gone fast -- we have been busy.

Today, my organization continues to exercise a singular responsibility, and remains accountable, for the safe and effective operation of 172 reactors -- ashore and afloat. It is the largest reactor program in the free world, with a cradle-to-grave responsibility for all aspects of naval nuclear propulsion. There are many subdivisions of that responsibility, but it all boils down to a fundamental requirement to establish and maintain two essential characteristics -- combat effectiveness and reactor safety.

From the beginning, Congress recognized the importance of central direction in this program. President Reagan's Executive Order of February 1982 articulated specific elements of the charter, and last year the Congress codified his directive.

Our program continues to expand as increasing numbers of nuclear powered ships join the fleet. The scope and difficulty of our work has also been affected by the increasing age of earlier ships and by the need to deal with an increasing number of decommissioned reactor plants. In spite of this, the size of my headquarters organization remains austere. The only growth has been in dedication and hard work.

SUBMARINE PROGRAMS

We how have 94 attack submarines and 36 ballistic missile submarines, including 5 TRIDENTs. 18 more SSNs and 7 more

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TRIDENTS are authorized. Five LOS ANGELES Class and one TRIDENT were added to the fleet last year. The Navy FY 1986 budget request includes one more TRIDENT and four additional LOS ANGELES Class submarines.

The Department of Energy must continue to oversee the construction and testing of propulsion plants for these ships. The Navy budget also provides for continued work on the new design attack submarine (SSN-21). My DOE budget supports Advanced Fleet Reactor development for this ship.

Last week we completed initial sea trials of ALABAMA -- our sixth TRIDENT submarine. The shipbuilder and the Navy crew did a good job -- the trials went well. Once again, I was impressed by what we were able to do with these ships, almost immediately, sometimes under adverse operating conditions that would tax even a seasoned crew. That was very clear during this trial because it was conducted in some of the worst storm conditions of the year. Fifty knot winds with twenty foot seas arrived in time for our initial dive, but the trial continued and the crew handled it well. A remarkable group -- as are the people associated with design, construction, and operation of our nuclear propulsion plants. I'll say more about that later.

Last year we decommissioned four submarines, bringing the total to ten. GEORGE WASHINGTON, our first Polaris submarine, was one of these - retired without fanfare after silently and effectively performing her mission of deterrence for more than twenty years. She never fired an armed missile. In the business of deterrence, that is the absolute definition of success.

SURFACE WARSHIPS

Last November, the nuclear powered aircraft carrier THEODORE ROOSEVELT was launched by Newport News. When commissioned in

1986, she will bring the Navy's CVN force to five. Construction of the two other authorized CVNs is ahead of schedule.

On the other hand, the Navy still has only nine nuclear-powered cruisers. No new ones have been authorized in over 10 years. That means only about one nuclear cruiser for each CVN when all seven become operational.

OPERATIONS

The performance of our nuclear powered ships continues to be remarkable. Their safety record has remained impeccable. They have now travelled over 60 million miles, from the North Pole, to the Indian Ocean, to Cape Horn, without a reactor accident or a release of radioactivity that has had a significant effect on the environment. Nuclear powered ships continue to work hard -- in fact, harder than most. A recent letter from one of the nuclear powered cruiser skippers reflects what nuclear propulsion meant to his deployed tempo of operations:

> COMSIXTHFLT significantly reduced Mediterranean operations because of potential over-expenditure of the FY 85 first quarter conventional fuel allocation. A majority of the battle group was in port by early or mid November and scheduled to stay in port through December for upkeep and maintenance. Many of the ships went cold iron to conserve additional fuel. The end result was the two nuclear powered ships deployed were underway 70% of last quarter while the conventional ships averaged about 30-40% of the deployment underway.

Another letter from a nuclear powered attack submarine Commanding Officer is also illustrative:

DALLAS departed Groton for a seven month Indian Ocean deployment on 18 May. We are moored to USS PROTEUS (AS-19) undergoing a scheduled 30 day upkeep, the only upkeep time scheduled during that seven months. Since leaving Groton, DALLAS has steamed 23,985 miles, operating 186 hours at full power.

By the time DALLAS returned home she had steamed over 58,800 miles on this deployment.

All of these ships maintain a high tempo of operations, but more important than how hard they run is what they do. Last year, you heard a top secret briefing that described several years of highly classified operations by our attack submarines. I won't go into detail again this year, but recently completed Polar operations by GURNARD and PINTADO are an example of the past year's work. These ships operated under the polar ice cap for over 48 days, conducting one of the most sophisticated and unique naval polar expeditions in history. Their job was to learn more about how to fight and survive in the most inhospitable environment in the world. They did well, in challenging round-the-clock schedules of tactical exercises, R&D testing and environmental data collection. Their operation culminated in surfacing together at the North Pole.

One of the strengths of our program has been our ability to integrate such experience into current and future nuclear powered submarines. It is one of the reasons that the SSN 637 Class, a 30 year old design, and the SSN 688 Class, a 20 year old design, can still handle the current Soviet threat.

Let me give you another example. Over ten years ago I was the sixth fleet submarine force commander during a major crisis in the Eastern Mediterranean. I had to commit a number of our SSNs

to difficult and potentially hazardous new tactics in support of our carrier battle groups. The submarines involved were commanded by young captains of great skill and tenacity, but one bears special mention. I cannot fully describe his mission because of its classification, but extracts from one of his messages to my headquarters provide a perspective:

FROM: USS WHALE

TO: COMMANDER TASK FORCE 69

1. BROKE OFF CONTACT AS MY TARGET ENTERED WEST CHANNEL. RAN AT FLANK TO REPOSITION, SURFACED TO FIX SAIL RATTLE, THEN SUBMERGED TO CONTINUE FLANK SPEED RUN, REGAINED CONTACT AT WEST END OF CHANNEL. SHORTLY AFTER REGAINING CONTACT, EXPERIENCED FIRE IN MAIN ENGINE LAGGING.

2. FIRE IS OUT. HAVE REGAINED CONTACT BEARING 271 T. NEED SEA ROOM TO THE WEST.

"Need sea room to the west" -- he had a lot to contend with, but the only help he asked for was more room to work.

That officer is now program manager for the new attack submarine. He knows what needs to be done because he has been there -- and he has the technical competence to ensure that such experience is factored into the new design.

NEW DEVELOPMENT

SSN-21 work is moving along well. Preliminary design of this ship is nearly complete and contract design will start later this year. Meanwhile, our DOE work on the propulsion plant continues on schedule. We are combining the results of ongoing DOE and Navy research and development with TRIDENT equipment design and

manufacturing experience to develop the most cost effective product.

Bettis Atomic Power Laboratory is the principal design agent, assisted by the Knolls Atomic Power Laboratory, and the Electric Boat and Newport News shipyards. They are working with other firms to produce the quietest, most powerful submarine propulsion plant yet fielded by this country. It will have to be, if we are to handle the 21st century threat against which the ship will ultimately be measured. SSN-21 must be fast, as well as heavily armed, and unlike earlier U.S. boats (and even the most recent Soviet designs), it will have to be extraordinarily quiet across its entire speed range. Finally, we must achieve this goal without sacrificing the fundamental principles of conservatism in design that have served this program so well for so long.

The overall task is an immense technical challenge. It is one we can handle, but only with your continued strong support.

NAVAL PERSONNEL

Thus far, I have dealt with the technical and operational aspects of our program, but none of what has been accomplished would have been possible were it not for the relatively small numbers of people who bring the ships to life and others who drive them into harm's way. The men who operate these ships must be very good at what they do. Wherever they go, they must expect to be outnumbered. If they're not outnumbered, they're probably in the wrong place.

That means we must develop crews and ships that can operate alone and unsupported, in waters controlled by the enemy. They must be able to do grievous harm, and survive in the face of overwhelming

odds. It takes a high performance ship to do all that, but more important, it takes a special breed of men. It doesn't take many. In the past 30 years the nuclear program has trained only about 10,000 officers and 50,000 enlisted men.

It is hard for most folks to comprehend, much less appreciate what we demand of these people; however, Joseph Conrad's description of "The Commanding Officer" is illustrative:

> In each ship there is one man who, in the hour of emergency or peril at sea, can turn to no other man. There is one who alone is ultimately responsible for the safe navigation, engineering performance, accurate gunfiring and morale of his ship. He is the Commanding Officer. He is the ship.
>
> This is the most difficult and demanding assignment in the Navy. There is not an instant during his tour of duty as Commanding Officer that he can escape the grasp of command responsibility. His privileges in view of his obligations are most ludicrously small; nevertheless command is the spur which has given the Navy its great leaders. . . .

"His privileges, in view of his obligations, are most ludicrously small. . . ." Those words really fit the whole crew, not just the CO.

Those of you who have gone to sea in a nuclear-powered ship know what I mean. You have met those guys in their own element, seen what kind of men they are, and understand what we ask of them and of their families. For those of you who have not had this experience, let me try to put submarine duty in perspective.

SHIPBOARD PERSPECTIVE

Imagine stuffing a corridor in this building with machinery, electronics gear, weapons, and all the food you need for four months, and then cramming 125 guys into it. Send them to sea for months at a time, without mail or contact with their families. Finally, reward them with hard work, long hours, little sleep, and the promise of long hours in refit upon their return.

A typical day at sea is not like anything other men do for a living -- anywhere. Both officers and men stand watch from six to twelve hours every day. In their spare time, they maintain their equipment and must satisfy the most rigorous training standards in the world. These kinds of demands are not unique to submarine duty; our nuclear operators throughout the fleet must stand up to the most compelling responsibilities and demands.

Why do they do it? You ought to visit one of our ships and ask them.

NUCLEAR TRAINING

The nuclear-trained officers and men in these crews are held to particularly tough standards. They must maintain a completely professional attitude on watch -- no small talk or nonwork-related conversation -- only constant attention to the operations of the reactor plant. There is never a minute without pressure, without thinking "What if" and "What will I do if. . . ."

They must understand and work with some of the most technologically advanced concepts and equipment in the world. All have passed a rigorous screening and selection process. Each has received six months of theoretical instruction by the Navy. The course is deliberately made tough to challenge and bring out

pass, but it is the only way to develop the fundamental understanding that is an essential prerequisite for safe operation of a nuclear propulsion plant.

But even that fundamental understanding is not enough. They must also become skilled operators, with an instinctive feel for the plant that can only be developed in an operating environment. That process begins ashore, at prototype plants under the direction of the Department of Energy. This is where our reactor operators undergo basic training on a real reactor and where they first learn the real consequences of their actions.

The process continues at sea, with advanced training in operating ships where they learn to deal with the unexpected and, if necessary, to "play hurt". Eventually they must reach the point where they can react to a casualty in a matter of seconds, achieve a stable condition, then fix what broke and restore the plant. And they have to do it alone, because it's a long way to the hardware store, and they cannot expect help from itinerant technical representatives.

The standards are high because the consequences of a mistake are grave. Any relaxation would be foolish at best, and at worst, most perilous. That is why I tend to lose patience when some folks suggest that we train new reactor operators on simulators. "Why not?" they say. "Wouldn't it be just as good -- and a lot cheaper?" The answer is no -- it would not be as good, and certainly not cheaper. It would be an unequivocal reduction in our standards, and the cost of inadequate training in this business is incalculable.

Experience has proven that our people can only develop adequate skill and the proper instincts in an environment where there are

real consequences for their actions. If a trainee makes a mistake he must know that he cannot recover by simply resetting a computer program. It is also important that the instructor have a real personal stake in his students' performance. Reactor operators must be trained under conditions which are identical to those they will encounter on board ship. At sea, a mistake may cost their lives, and those of their shipmates. In port, it could have broader, and perhaps even graver consequences.

COMMANDING OFFICERS

Commanding Officers deserve special mention. As junior officers, they have all been through all of the training I have described, and more. Each has served in many jobs on a number of ships. Each has qualified as an Engineer Officer. They must then survive a very competitive screening process, first for assignment as Executive Officer, then to command. The only exception to this sequence is for CVN Commanding Officers who undergo nuclear power training after having been selected for assignment as an Aircraft Carrier Executive Officer. Each officer selected for command undergoes 3 months of concentrated study and examination in my office before he can assume command. When he gets to his ship, he will have to serve longer in the job than any other Commanding Officer in the Navy.

They are the best of their profession, and they carry immense personal responsibility for the safe operation of one or more nuclear reactors, in port as well as at sea. They must also be ready to do the unthinkable -- to unleash their weapons if called upon by duly constituted authority. All the while, they understand better than most, the personal as well as national consequences of such an action.

You should ask yourselves what kind of men you want to carry such responsibility. Ask the question not just of the CO, but of his entire crew, then consider what should be done to ensure that we will have such men when we need them.

HEADQUARTERS PERSONNEL

Congress, recognizing that these men are a principal reason for our success, has supported a number of important initiatives to help retain these operators. But the operators must also have the tools to do the job, and that would not be possible without the support of the most capable technical organization in the world. Admiral Rickover built it -- and his legacy remains intact. Many of my most experienced and knowledgeable senior engineers have been in the business for more than 20 years. In that time, their responsibilities have grown immeasurably, while the size of the staff has remained the same. One must wonder why these people remain in government, when they could easily earn considerably more in the private sector. There is no easy answer to that, but I believe they stay because they are committed to excellence, can demand it of others, and because they believe in what they do. They know their worth, but they do not ask it.

SUMMARY

Most of this statement has focused on the subject of people, because it is important for you to understand what they mean to this program, and to this country. They know their worth, but they are too few and too busy to sound the trumpet. They depend on you, and their success is <u>your</u> legacy. Without your continued support and understanding the Navy might find all its nuclear-powered ships -- over 40% of its combatant strength -- at risk without the first shot having been fired by a potential enemy.

BUDGET

We must also give them the tools to do the job. Our budget request is structured to do that. The total for Fiscal Year 1986 comes to $569 million. You will observe that represents an increase over last year, but please recall that there was no growth in my FY 1985 budget.

$489 million of the total is for operating expenses. Principal categories of that work include:

- Research, development, and support work needed to keep the existing nuclear power plants running safely;

- Operation, maintenance, and servicing of the prototype plants, which we use for research and development and for training; and

- Continuation of our work on the Advanced Fleet Reactor for the new attack submarine.

Also included in the request is 30 million dollars for capital equipment and 50 million dollars for construction project funding. The construction funds are to complete two projects and for one minor new project involving modifications to a test reactor facility.

FY 1986 DEPARTMENT OF ENERGY

BUDGET REQUEST

FOR THE

NAVAL REACTORS DEVELOPMENT PROGRAM

The Naval Reactors Development program involves design, development, improvement, testing, and evaluation of nuclear propulsion plant components and reactor cores. The goals of this effort are: to enhance the performance and reliability of naval reactors while simplifying operating and maintenance requirements; and to design and develop advanced reactors for use in improving the capability of present and future nuclear powered naval warships. Throughout all design and development work, plant safety and reliability are of paramount concern.

Currently powering over 40% of the Navy's combatant vessels, nuclear propulsion plants enable these ships to operate alone and unsupported, limited only by their weapons load and crews' endurance. As potential adversaries continue to make strides in nuclear propulsion technology, continuing improvement of our naval nuclear propulsion plants is critical to maintaining our advantage in this vital National defense area.

Consequently, ongoing efforts aim at developing advanced reactors with improved performance. Specific performance objectives are: increasing maneuverability; improving quieting; reducing ship transit time to and from stations; increasing overall effectiveness in a combat situation; increasing ship operating availability; reducing the need for costly refueling and servicing operations; minimizing the production of nuclear waste; and reducing personnel radiation exposure.

Effort is being applied to the Advanced Fleet Reactor which will power the next generation of nuclear powered attack submarines.

The Advanced Fleet Reactor will concentrate many of the current advances in reactor concepts, components and materials generated from ongoing development effort.

Other major or associated developmental work includes a Modified Fuel Process for producing improved fuel elements which will increase reactor life and power; a higher power, longer life core for shipboard application; a Submarine Test Core and Developmental Materials Core to test improved reactor fuels, materials, and configurations intended to provide improved plant performance; and development of advanced plant concepts which offer improved power characteristics and reduced detectability.

Development and analysis work continues beyond the point where a plant system or component is introduced into fleet use. The operating life of this equipment may exceed 30 years. During this time, work continues to assess and evaluate material performance, ensure safety, and understand long term phenomena. Work also goes on to develop, test, and apply improved cores, components, and systems to existing plants. Operating data obtained from equipment in the fleet provides a valuable source of information in the development of new plants, components, and systems.

The Program operates eight land based prototype nuclear propulsion plants which are integral to the development, testing, analysis and evaluation of new reactor cores, components, materials and concepts and to the training of Navy operators. Once a plant or component goes into operation in the fleet, the prototype plants provide empirical data on plant performance ahead of fleet experience. This allows assessment of long term performance, special testing, and determination and resolution of any problems before they are encountered in fleet units.

The Fiscal Year 1986 Naval Reactors Development budget request is $569 million, a $72.1 million increase over the Fiscal Year 1985 budget. The increase is due primarily to: escalation; increased prototype servicing effort as the overhaul and refueling activity enters its busiest phase; final funding for the Modifications and Additions to Prototype Facilities project; development and fabrication of Advanced Fleet Reactor prototype equipment; and modernization and upgrading of the Advanced Test Reactor.

The details of the request by major area are:

		Budget Authority (in millions)
Reactor Development		
Operating Expenses	$261.3	
Capital Equipment	30.0	
Construction	50.0	
Subtotal		$ 341.3
Plant Development		
Operating Expenses		66.0
Reactor Operation and Evaluation		
Operating Expenses		150.0
Program Direction		
Operating Expenses		11.7
TOTAL NAVAL REACTORS DEVELOPMENT		$ 569.0

The following discussion summarizes the work in these major areas:

REACTOR DEVELOPMENT

Reactor Development aims at improving the power, reliability, and endurance of naval reactors. Experience gained from operating reactors is applied to development of new reactor designs, concepts, and materials which can be incorporated into existing or new design reactors. Advanced concepts resulting from applied research and emergent technological advances are also used in improving naval reactor capabilites and ensuring the longevity of naval reactor plants. Analysis of each type of reactor continues as long as a unit continues in use to assure plant safety and assess operational criteria.

New and improved reactor fuels and materials are basic requirements for enhanced reactor power and endurance. Physics and fuel characteristic studies and tests determine optimum core arrangements and fuel attributes. Better fuel manufacturing processes and fabrication techniques allow use of more capable reactor fuels and more accurate prediction and determination of core operating characteristics, thus permitting better use of potential reactor power. Since even small amounts of material corrosion and distortion can significantly contribute to reduced core performance and lifetime, developing new materials, determining reactor material characteristics, and understanding phenomena such as embrittlement are instrumental in realizing the potential gain in performance from the new fuels.

Design and development of advanced reactor cores is an iterative process with multiple data sources. Analytic models aid in the design and development of advanced reactors and evaluating reactor performance. Data from these models and operating fleet plants, test results from the prototypes plants, and information obtained from examining spent reactor cores, are vital to maximizing the performance of new reactor plants.

The premier Naval Nuclear Propulsion Program development effort is the Advanced Fleet Reactor. The Advanced Fleet Reactor will feature a higher power reactor in addition to incorporating the latest quieting techniques. At the same time, the Advanced Fleet Reactor will be designed to ensure simpler and more reliable operating characteristics. Although Advanced Fleet Reactor work involves almost all technical areas, the bulk of the effort is reactor development work. Specifically, Advanced Fleet Reactor work in FY 1986 includes: completing critical experiments and final nuclear design; continuing fuel and poison element production for the prototype core; initiating control rod preassembly and preproduction; and designing and fabricating test models, instrumentation, and prototype and test components.

Other Reactor Development work in FY 1986 will include: initial vendor development for fabrication of the Developmental Materials Core; completion of the Submarine Test Core; development of advanced plant concepts; examination of expended cores and irradiated test specimens; evaluation of material corrosion behavior; continued development of the Modified Fuel Process; continued qualification of noise and vibration design procedures; and testing of prototypic components.

CAPITAL EQUIPMENT

Capital equipment requirements for Fiscal Year 1986 include upgrading and replacement of antiquated operating equipment, modifications to prototype systems, additional computing equipment and prototype instrumentation and control equipment. Improved and replacement laboratory equipment, components, and systems are required to continue advanced development and reliable test operations. New computer equipment will replace obsolete equipment and provide up-to-date capability for use in the design and development of advanced reactor plants.

CONSTRUCTION

In Fiscal Year 1986, major construction funds are requested for final funding of two projects: the Modifications and Additions to Prototype Facilities, project number 81-T-112, which provides for modifying and adding engineered control features to several prototype plants; and the Materials Facility, project number 82-N-111, which will provide a second source for the manufacture of naval nuclear fuel. The FY 1986 budget also includes initial funding of Reactor Modifications to Advanced Test Reactor (ATR), project number 86-N-104, which will provide for the upgrade of systems critical to the reactor's operation, including the replacement and refurbishment of systems in the control room.

PLANT DEVELOPMENT

Plant Development aims at improving overall propulsion plant performance. The overall performance of a nuclear propulsion plant is dependent upon the combined capabilities of all systems, equipment and components in the plant and not just the reactor. Therefore, to fully benefit from the gains in reactor performance, corresponding improvements must be made to all other plant components and systems.

To ensure that a reactor plant is both reliable and safe, a thorough understanding of structural materials corrosion and stress parameters is necessary. New materials and materials used in existing plants are tested and evaluated in special facilities and prototypes. Recognizing that water chemistry is a major factor in corrosion, work continues to develop a fluid environment that minimizes material corrosion and crud buildup.

In FY 1986, Naval Reactors will continue Plant Development efforts, including: developing the next generation of

instrumentation, control and electrical equipment: developing, testing and evaluating reactor plant components and component materials; developing and testing alternate chemistries to minimize corrosion of secondary plant materials; upgrading casualty control systems; designing, testing and qualifying advanced system concepts; and operating multi-purpose test facilities for use in evaluating new materials and improving plant performance.

REACTOR OPERATION AND EVALUATION

Reactor Operation and Evaluation encompasses the operation of eight prototype naval nuclear propulsion plants and associated testing and evaluation. These plants serve a number of purposes. First and foremost among them is the testing of developmental cores, components, and plant systems in an actual prototypic operating environment. The prototype plants allow operational testing prior to introduction into fleet service and provide experience ahead of equipment installed in the fleet. Experimental concepts are also tested.

The information gained from prototype operation is used to confirm design specifications and parameters, and when discrepancies appear, to evaluate and aid in resolution of any matter warranting attention. Even after a plant, component, system, or core is introduced into the fleet, it will continue to be tested in a prototype. Equipment is followed until the end of its service life to determine actual end-of-life performance. Life cycle testing is an important consideration in view of the long life of reactor cores and plants. All prototype plants are fully instrumented to provide data needed to evaluate reactor plant equipment. Accelerated life tests carried out prior to committing a new plant, core, component or system to service, serve a useful purpose, but are at best approximations, and do

not substitute for operating in a normal manner over an actual lifetime.

As with any operating machinery, the prototype plants must be serviced. Servicing includes routine maintenance, refueling, component removal and replacement, and plant and systems overhaul. The techniques and devices used and refined in prototype servicing operations provide a place to try out new servicing techniques and equipment and serve as the guide for carrying out fleet servicing work.

For FY 1986, Reactor Operation and Evaluation work will include: operation, testing and routine maintenance of the prototype plants; completion of the S5G prototype plant overhaul and refueling; completion of the D1G prototype plant interim inspection and overhaul; performance of an overhaul on both A1W prototype plants; preparation for the S3G prototype plant overhaul and refueling; completion of the S5G prototype plant overhaul and refueling; performance of an extended maintenance shutdown on the S1W plant; continued preparation and development of reactor servicing procedures, techniques, and equipment; and application of these procedures, techniques, and equipment to fleet servicing activities.

PROGRAM DIRECTION

Program Direction provides for salaries, benefits, travel and other expenses for 213 full time Federal employees at the Naval Reactors, Pittsburgh Naval Reactors, and Schenectady Naval Reactors Offices.

The Naval Reactors Development program has cradle-to-grave responsibility for all aspects of nuclear propulsion. That

responsibility increases in proportion to the growing number of nuclear powered ships. Naval Reactors personnel maintain close program management and technical direction of all the varied program activities.

Naval Reactors staffing is austere. Through careful management, the existing manning level has been able to accommodate changing workscopes and increasing demand. Improvements in work force productivity have been achieved over the years, despite increasing workload, by effective use of available staff.

APPENDIX B

Department of Energy
Washington, D.C. 20585

MAY 2 6 1985

MEMORANDUM TO: Admiral J. O. Bobus, NE-40

FROM: Leon Blinconstein
Associate Deputy Assistant Secretary
for International Nuclear Energy
and Defense Programs

THRU: Jo Ann Williams, Director
Office of General Counsel

SUBJECT: Review of Responsibilities and Authorities of the Office of Naval Reactors, Department of Energy, for Overseeing Naval Nuclear Propulsion Matters in the Department of Defense

Purpose: The purpose of this memorandum is to advise you of the results of our review of the responsibilities and authorities of the Office of Naval Reactors of the Department of Energy (DOE) to monitor the operations of naval reactors by the Department of Defense. This review was requested by your office because of a memorandum dated January 10, 1985, to a similar matter from Vice Commander, Executive Level Activities for the Nuclear Weapons Commission (NWC), to Edson Case, Deputy Director of the Office of Nuclear Reactor Programs. The scope of this memorandum and its enclosure, an NRDC Memorandum, was restricted by the N.Y. Times specific requirement that copies of the file of the Office of Naval Reactors be maintained and open for public review consistent with the granting of nuclear propulsion technology.

Discussion: We have reviewed the NRC memorandum to determine the principal assertions that the NRC has with a view to evaluating the Department of Defense in providing technical advice to naval nuclear propulsion matters upon request. The discussion in the NRC memorandum of DOE's authorities and responsibilities is appropriate and helpful in the understanding of the unique role of the Office of Naval Reactors and how it evolved. In this memorandum, we have elaborated on this discussion and provided additional comments concerning the Office of Naval Reactors' role with regard to other offices within DOE and other offices within the DOD.

Public Energy Act of 1959

The Atomic Energy Act of 1954 established the framework for controlling all activities pertaining to the use of special nuclear material by the United States. Section 91.b., 110, 161.h. and 161.i. of the Act are relevant to the current issue.

Many nuclear propulsion reactors and special nuclear material which are delivered to or acquired by DOD pursuant to a Presidential directive issued under Section 91.b. are exempt from licensing under Section 110. These sections do not, however, explicitly delineate the responsibilities which the Atomic Energy Commission may have had relative to the health and safety of the public for such non-licensed activities. However, other parts of the Act, specifically Sections 161.h. and 161.i., gave the AEC broad-ranging authority which extended to all uses of special nuclear material, source material, and byproduct material. Sections 161.h. and 161.i., respectively, provide as follows:

> In the performance of its functions the Commission is authorized to *** establish by rule, regulation, or order, such standards and instructions to govern the possession and use of special nuclear material, source material, and byproduct material as the Commission may deem necessary or desirable to promote the common defense and security or to protect health or to minimize danger to life or property. (Section 161.h.)

> In the performance of its functions the Commission is authorized to *** prescribe such regulations or orders as it may deem necessary *** to govern any activity authorized pursuant to the Act, including standards and restrictions governing the design, location and operation of facilities used in the conduct of such activity, in order to protect health and to minimize the danger of life or property. (Section 161.i.)

In an effort to better define AEC and DOD responsibilities on public health and safety matters, President Kennedy issued a Presidential Directive on September 23, 1961. 1/ The Directive states that:

1/ The AEC's General Counsel, in a memorandum dated February 17, 1964 circulated to the Atomic Energy Commission as 1067/17), stated in part:

> "The legal responsibilities of the Commission and the DOD for safety (for Section 91.b. reactors and the special nuclear material used to fuel them) now stem from the (Footnote Continued)

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"Responsibility will rest with the Department of Defense for identifying and resolving health and safety problems relating to the operation of utilization facilities, or to special nuclear material for use therein, which are held by the DOD pursuant to directives of the President under Section 91b of the Atomic Energy Act. In view of the Atomic Energy Act of 1954, the AEC will participate in the identification and resolution of these problems as a matter of responsibility. In this connection, the Department of Defense or the appropriate military Department will prepare, issue, and enforce safety standards, procedures or instruction applicable to the location and operation of utilization facilities and to special nuclear material for use therein. Advice and assistance will be obtain from the AEC on the safety aspects of the design of utilization facilities and in the preparation or amendment of safety standards, procedures, or instructions relating to the location and operation of utilization facilities and to special nuclear material for use therein, and comment or concurrence shall be obtained from the AEC as to their adequacy. Any disagreement as to the safety aspects, arising as a result of comment by the AEC, which cannot be directly resolved by the two agencies will be referred to the President for decision."

The Directive clearly recognizes the important role which the AEC had in ensuring the safe operation of military reactors. At the same time, the Directive establishes that in operating military reactors, the Department of Defense is the agency principally responsible for their safe performance. Before and after the Directive, the AEC carried out its health and safety responsibilities for the naval reactor program by relying on its

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(Footnote Continued)
Presidential Directive of September 23, 1961. While that directive is not free of ambiguity in total context it places primary responsibility on the DOD and only secondary responsibility on the Commission."

As far as we have been able to determine, this directive remains in effect. Under Section 27 of the Atomic Energy Act of 1954, the President has the authority to make a final decision regarding AEC (and its successors)/DOD responsibilities under Section 91.b.

Naval Reactors Division as well as on its "Regulatory Side" 2/ to provide technical advice on request.

The Naval Reactors Division was assigned the responsibility for the design and development of naval nuclear propulsion reactors, overseeing their safe operation, and ensuring the safe handling and use of all special nuclear material and byproduct material pertaining to their safe operation. The evolution of that division and the methods which it used to fulfill that responsibility are described in more detail below.

Energy Reorganization Act of 1974

The Energy Reorganization Act of 1974 transferred to the newly-created Nuclear Regulatory Commission "all the licensing and related regulatory functions of the Atomic Energy Commission" (Section 201(f)) and transferred all other functions of the AEC to the Administrator of the Energy Research and Development Administration (Section 104(c)). The Naval Reactors Division and all of its functions transferred to ERDA where it became the Division of Naval Reactors.

The Energy Reorganization Act did not substantively change the role that the AEC's successor agencies, the ERDA and NRC, played with respect to special nuclear material and utilization facilities acquired by the military pursuant to Section 91.b. As the NRC counsel's memorandum points out, NRC continued to provide technical advice in selected areas for two reasons.

First, while the Energy Reorganization Act does not address in explicit terms the question of the obligation of the newly-created NRC to continue to provide the technical advice to DOD which the "Regulatory Side" of the AEC had been providing for many years, it does indicate in its transitional provisions that the Congress expected the newly-created NRC to do so.

Second, Section 301(b) of the Energy Reorganization Act is a "savings" clause that continues the effectiveness of all existing orders, determinations, rules, regulations, permits, contracts, licenses and privileges affected by that Act. Its purpose was to avoid any inadvertent lapsing or impairment of essential Executive orders, directives, documents, and obligations, so as to afford the President, the Administrator, or other officials sufficient time to deal with these matters in an orderly fashion. The Presidential directive of September 23, 1961 previously

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2/ See OELD Analysis for a description of the AEC's "Regulatory Side".

discussed was one of the directives preserved by Section 301(b) and the "Regulatory Side's" overall obligation under that directive were assumed and carried out by the NRC.

Department of Energy Organization Act of 1977

The Department of Energy (DOE) was created pursuant to the Department of Energy Organization Act of 1977, absorbing ERDA's responsibilities into the new agency. The Division of Naval Reactors was transferred to DOE by Section 309(a) of the Act, which states as follows:

> "The Division of Naval Reactors established pursuant to Section 25 of the Atomic Energy Act of 1954, and responsible for research, design, development, health, and safety matters pertaining to naval nuclear propulsion plants and assigned civilian power reactor programs is transferred to the Department of Energy . . ."

It is clear from this section, which briefly summarizes the long-standing responsibilities of the Division of Naval Reactors, that those responsibilities addressed all aspects of the use or handling of special nuclear material and byproduct material pertaining to naval nuclear propulsion.

Section 301 of the Department of Energy Organization Act is a "savings" clause that continues in the DOE the functions performed by ERDA under the 1961 Presidential Directive. It states:

> "Except as otherwise provided in this Act, there are hereby transferred to, and vested in, the Secretary (of Energy) all of the functions vested by law in the Administrator of the Energy Research and Development Administration . . ."

Executive Order 12344 of February 1, 1982

Presidential Executive Order 12344 of February 1, 1982 (Tab B) confirms the dual existence of the Office of Naval Reactors within both DOE and the Department of Navy. 3/ The principal intent of the Order is to:

3/ The Executive Order and the current organizational arrangement within the DOE and the Navy has resulted in the head of the Office of Naval Reactors being given three titles, which are presented here for completeness:

(Footnote Continued)

"...preserve the basic structure, policies and practices developed for the [Naval Nuclear Propulsion Program] in the past and assuring that the Program will continue to function with excellence..."

This mandate again demonstrates Presidential intention that the practices which had been developed over the years, such as NRC consultation on selected matters, not be modified.

Section 5 of Executive Order 12344 goes on to recognize the long-standing statutory responsibilities of the Naval Nuclear Propulsion Program by directing that "within the Department of Energy, the Secretary of Energy shall assign to the director the responsibility of performing the functions of the Division of Naval Reactors transferred to the Department of Energy by Section 309(a) of the Department of Energy Organization Act (42 U.S.C. 7158), including assigned civilian power reactor programs, and any naval nuclear propulsion functions of the Department of Energy, including:

(c) the safety of reactors and associated naval nuclear propulsion plants, and control of radiation and radioactivity associated with naval nuclear propulsion activities, including prescribing and enforcing standards and regulations for these areas as they effect the environment and the safety and health of workers, operators, and the general public."

This health and safety (Section 5(c)) oversight authority appears to be derived from Section 161.b. and 161.i. of the Atomic Energy Act of 1954, the oversight aspects of which were transferred with

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(Footnote Continued)

(1) The Office of Naval Reactors, headed by the Deputy Assistant Secretary for Naval Reactors, is the official DOE organization;

(2) The Nuclear Propulsion Directorate of the Naval Sea Systems Command, headed by the Deputy Commander for Nuclear Propulsion, is the Navy organization;

(3) The Naval Nuclear Propulsion Program, headed by the Director, is the joint DOE/Navy title for the entire organization, and it encompasses all activities pertaining to naval reactor propulsion.

Each of these descriptions refers to the same organization in different contexts; one person, currently Admiral K.R. McKee, holds all of the titles.

the Division of Naval Reactors in the case of naval reactors (since they are not licensed) to the ERDA by the Energy Reorganization Act of 1974, and thereafter to the DOE by the Energy Organization Act of 1977, as described above.

The provisions of Executive Order 12344 were codified by Section 1634 of the Department of Defense Authorization Act of 1985.

Relationship With Other DOE Offices

The official DOE delineation of the Office of Naval Reactors' charter both within the Office of Nuclear Energy and as an interface with other DOE oversight organizations such as the Office of Policy, Safety, and Environment is completely consistent with the responsibilities and authorities discussed above. This is best demonstrated perhaps by a brief discussion of recent Secretarial-directed efforts to strengthen the safety and environmental protection activities both in the line organizations and in the Headquarters Office of Environment, Safety, and Health. As an outgrowth of that effort, memoranda were generated by the Principal Deputy Assistant Secretary for Nuclear Energy (NE-2), the Assistant Secretary for Policy, Safety , and Environment (PE-1), and the Special Assistant to the Secretary for Policy and Programs reaffirming the traditional responsibilities and authorities of the Office of Naval Reactors.

In a memorandum dated July 2, 1984, to the Field Office Managers, Program Secretarial Offices, and the Assistant Secretary for Management (Tab C), the Special Assistant to the Secretary for Policy and Programs discussed potential initiatives for strengthening of the DOE Headquarters safety organization and forwarded an attachment discussing modifications required in several DOE orders to accomplish that purpose. His memorandum also indicated that PE-1 had been charged by the Secretary with establishing a task force to explore ways for improving the Headquarters independent safety organization.

In a memorandum dated July 19, 1984 responding to the Special Assistant's memo (Tab D), the Principal Deputy Assistant Secretary for Nuclear Energy stated his understanding of the effort with respect to the Office of Naval Reactors as follows:

> "Finally, it is our understanding that the effort referred to in the subject memorandum should not apply to facilities under the cognizance of the Office of Naval Reactors (NR). The actions being contemplated for Headquarters safety oversight have been and continue to be carried out by the Deputy Assistant Secretary for Naval Reactors for NR facilities. This was recognized in that the Crawford Committee review specifically excluded the NR prototype reactors and appropriate functional and exclusionary

language was included in the DOE directives issued after the review. Since then, nothing has occurred to alter this arrangement. Indeed these basic safety responsibilities have been codified for Naval Reactors in Presidential Executive Order 12344 issued February 1, 1982. Accordingly, existing functional and exclusionary language for Naval Reactors should remain in the pertinent DOE Orders. The Deputy Assistant Secretary for Naval Reactors continues to be responsible for all safety aspects of design, fabrication and operation of NR facilities including establishment of program requirements for, and oversight of, such areas as nuclear safety, quality assurance, environmental protection, control of radiation and radioactivity, and emergency preparedness."

The Special Assistant to the Secretary for Policy and Programs in a memorandum dated August 13, 1984, (Tab E) to you confirmed that the efforts to strengthen the Headquarters safety organization did not change the responsibilities or authority exercised through the Office of Naval Reactors. He states as follows:

"...regarding our efforts to strengthen the DOE Headquarters independent safety organization, you specifically noted ...past Departmental practices where the Office of Naval Reactors would continue to be responsible to the Secretary for safety and environmental oversight of Naval Reactors program activities. These practices are reflected in provisions of both existing DOE orders and Presidential Executive Order 12344.

Jan Mares, Jim Vaughan, and I have all reviewed this matter and agree that continuation of the present Naval Reactors role is both necessary and appropriate. As reflected in ASPE's follow up memorandum of August 3, 1984, on this subject, no change is planned in the responsibilities and authorities related to Naval Reactors activities. Any revisions to the DOE orders will retain the existing functional and exclusionary language outlining the Naval Reactors responsibilities. I have discussed this matter fully with the Secretary and he concurs."

DOE Orders 5480.1A, Environmental Protection, Safety, and Health Protection Program for DOE operations and DOE Order 5482.1A, "Environmental Protection, Safety, and Health Protection Appraisal Program" are the key DOE Orders that set forth the functional and exclusionary language which recognizes Naval Reactors responsibilities.

Relationship With Other Navy Offices

The official Navy delineation of the Office of Naval Reactors' charter is consistent with Executive Order 12344, discussed above. As required by Section 9 of that Executive Order, the Director, Naval Nuclear Propulsion Program reports to the Chief of Naval Operations and has direct access to the Secretary of the Navy and other senior officials in the Department of the Navy concerning naval nuclear propulsion matters, and to all other Government personnel who supervise, operate or maintain naval nuclear propulsion plants. OPNAV Notice 5430 dated February 8, 1982 that effected and announced the establishment of the Director, Naval Nuclear Propulsion Program, within the Office of the Chief of Naval Operations as well as his responsibilities under the Executive Order is at Tab F.

OPNAV Instruction 3000.5 Series entitled "Operation of Naval Nuclear Powered Ships" provides general guidance for the operation of naval nuclear powered ships and craft, and specific guidance regarding port entry matters. 4/ The instructions describe the interrelationship of the responsibilities of the Chief of Naval Operations, Fleet Commanders in Chief, and the Director, Naval Nuclear Propulsion Program. The instructions identify the traditional role of the Chief of Naval Operations for establishing policy for and controlling the operation of naval nuclear powered ships and authorizing all port entry activities as well as all other operations with possible reactor safety implications to the public. The instructions set forth the numerous responsibilities of the Director, Naval Nuclear Propulsion Program including safety of naval reactors and associated naval nuclear propulsion plants; control of radiation and radioactivity associated with the naval nuclear propulsion activities, including prescribing and enforcing standards and regulations for these areas as they affect the environment and the safety and health workers, operators, and the general public; oversight of Naval Nuclear Propulsion Program support in areas such as emergency planning for accidents associated with naval reactors and nuclear propulsion aspects of port entry; and providing, as appropriate, technical direction and assistance to the Fleet Commanders in Chief in operation and inspection of naval nuclear powered ships.

The Director, Naval Nuclear Propulsion Program, therefore, has oversight responsibility and authority for all matters pertaining to reactor safety of nuclear warships in his Navy, as well as his DOE, capacity.

4/ The current instruction, 3000.5C, is dated June 1978; it is currently in revision to reflect the issuance of E.O. 12344 and

(Footnote Continued)

Conclusion: In view of all the foregoing, we have no basis to disagree with the principal conclusion of the NRC counsel's memorandum, namely, that the NRC has an obligation pursuant to the Atomic Energy Act, the Energy Reorganization Act, and the 1961 Presidential Directive to provide technical advice on health and safety matters concerning Navy nuclear propulsion reactors when requested by the DOE.

We also conclude that the Office of Naval Reactors has responsibilities derived from the Atomic Energy Act, the 1961 Presidential directive, and Executive Order 12344 to oversee the safe operation of naval nuclear propulsion plants. The Navy has immediate responsibility for operation of naval nuclear powered ships, but the safety aspects relative to use of these military reactors are subject to review by the DOE and NRC as a matter of responsibility.

The Office of Naval Reactors fulfills DOE's responsibilities in this area through inter alia the direct involvement of that office and its DOE contractors in the central headquarters technical control over design and modification of naval reactors, preparation and issuance of nuclear propulsion plant operating procedures, the oversight afforded to construction, testing, inspection, refueling, overhaul and decommissioning work on nuclear powered ships, the selection, training and qualification of naval nuclear propulsion plant operators, and oversight of the actual operation of the plants themselves.

With respect to the berthing of nuclear powered ships, the Office of Naval Reactors has the authority to carry out those responsibilities exercised by the AEC Naval Reactors Division. These include overseeing Navy activities pertaining to port entry matters.

(Footnote Continued)
the title Director, Naval Nuclear Propulsion Programs, which was established pursuant to that Order.

UNITED STATES
NUCLEAR REGULATORY COMMISSION
WASHINGTON, D. C. 20555

JAN 20 1981

MEMORANDUM FOR: Edson G. Case, Deputy Director
Office of Nuclear Reactor Regulation

FROM: Guy H. Cunningham, III
Executive Legal Director

SUBJECT: NRC OBLIGATION TO PROVIDE TECHNICAL ADVICE ON HEALTH AND SAFETY MATTERS CONCERNING NAVY NUCLEAR PROPULSION REACTORS WHEN REQUESTED BY THE DOD

This responds to your request for OELD views on NRC's obligation, if any, to provide technical advice on health and safety matters concerning Navy nuclear propulsion reactors when requested by the DOD. These reactors and the special nuclear material used therein are held by the DOD pursuant to directives of the President under Section 91b. of the Atomic Energy Act of 1954. As such, neither these reactors nor the special nuclear material are licensed under that Act. From the beginning of the Nuclear Navy program in 1946 until the present, such technical advice has been furnished by the NRC or its predecessors when requested.

For the reasons summarized in the OELD analysis, which is attached, I am able to advise you that until the Congress or the President indicates otherwise, the NRC has an obligation to continue to provide such technical advice upon request, subject, of course, to priority being given as needed to the agency's licensing and related regulatory responsibilities under the Atomic Energy Act of 1954, as amended, and the Energy Reorganization Act of 1974.

Guy H. Cunningham, III
Executive Legal Director

Attachment:
OELD Analysis

OELD ANALYSIS

Question: What obligation, if any, does the NRC have to provide technical advice on health and safety matters concerning Navy nuclear propulsion reactors when requested by the DOD?

Background

In 1947, when the AEC began its operations, a Reactor Safeguards Committee was established as an advisory committee of recognized experts to provide the agency with independent evaluation of the hazards aspects of existing reactors, as well as plans for new reactors. In 1950, a second Advisory Committee on Reactor Locations Problems was appointed. This Committee undertook to study sites of Government reactors and to evaluate environmental factors of reactor hazards. Thereafter, in July 1953, these two advisory committees were consolidated into the Advisory Committee on Reactor Safeguards (ACRS). The ACRS was made a statutory advisory committee in 1957 by an amendment to the Atomic Energy Act of 1954 (Public Law 85-256). In mid-1955, a full-time reactor hazards evaluations staff was created in the AEC's newly established Division of Civilian Applications. That Division was the beginning of the "Regulatory-side" of the AEC which eventually, under the Energy Reorganization Act of 1954, became the NRC.

For purposes of this memorandum, some type of technical advice concerning Navy nuclear propulsion health and safety matters has consistently been provided to DOD upon request.

Atomic Energy Act

Any obligation that the NRC may have to provide technical advice in the area that is the subject of this memorandum would derive initially from the Atomic Energy Act. Two sections of the Atomic Energy Act of 1954, sections 91b. and 161b. bear on this problem. For present purposes, Navy propulsion reactors and special nuclear material which are delivered to or acquired by DOD pursuant to a Presidential directive issued under Section 91b. are exempt from licensing under Section 110. This exemption, however, did not itself end the matter of whatever responsibilities the Atomic Energy Commission may have had for the health and safety of the public. Section 161b. of the Atomic Energy Act of 1954 provides:

> In the performance of its functions the Commission is authorized to * * * establish by rule, regulation, or order, such standards and instructions to govern the possession and use of special nuclear material, source material, and byproduct material as the Commission may deem necessary or desirable to promote the common defense and security or to protect health or to minimize danger to life or property.

For the naval reactors' program, the Atomic Energy Commission carried out its health and safety responsibilities by relying on its Naval Reactors Division,

as well as on the tasks assigned to its "Regulatory-side" to provide technical advice upon request.

The tasks assigned to the "Regulatory-side" of the AEC in this area continued without interruption subsequent to the Presidential Directive of September 23, 1961 which assigned responsibilities to the AEC and to the DOD for safety in this area.1/

1/ The directive states:

> Responsibility will rest with the Department of Defense for identifying and resolving health and safety problems relating to the operation of utilization facilities, or to special nuclear material for use therein, which are held by the DoD pursuant to directives of the President under Section 91b of the Atomic Energy Act. In view of the Atomic Energy Act of 1954, the AEC will participate in the identification and resolution of these problems as a matter of responsibility. In this connection the Department of Defense or the appropriate Military Departments will prepare, issue and enforce safety standards, procedures or instructions applicable to the location and operation of utilization facilities and to special nuclear materials for use therein. Advice and assistance will be obtained from the AEC on the safety aspects of the design of utilization facilities and in the preparation or amendment of safety standards, procedures or instructions relating to location and operation of utilization facilities and to special nuclear materials for use therein, and comment or concurrence shall be obtained from the AEC as to their adequacy. Any disagreement as to safety aspects, arising as a result of comment by the AEC, which cannot be directly resolved by the two agencies will be referred to the President for decision.

Thus, in carrying out its responsibilities for local production decisions from licensing under Sections 103, and 105, the Public Energy Commission will be part on the technical advice provided by its "Regulatory staff".[2]

Energy Reorganization Act of 1974

This is how things stood at the time of enactment of the Energy Reorganization Act of 1974. That Act transferred to the NRC) created by that Regulatory Commission "all the licensing and related regulatory functions of the Atomic Energy Commission" (Section 201(f)) and transferred all other functions of the AEC to the Administrator of the Energy Research and Development Administration (Section 104(c)). The division of local functions was transferred this to ERDA to AEC and subsequently, upon the enactment of the Department of Energy Organization Act in 1977, to the DOE.

2/ The NRC's General Counsel, in a memorandum dated February 25, 1982 circulated to the Atomic Energy Commission in SECY-77, stated, in part:

> The legal responsibilities of the Commission and the NRC staff, its duties, its duties are distinct and the Commission should not be the NRC staff and the NRC staff should be independent attorneys of Commission, NRC, NRC, and its attorneys to its role of advising it and other bodies of its legal advice or responsibility in the NRC and its staff as their responsibility of the Commission.[3]

As far as we have been able to determine, this practice remains in effect. Under Section 27 of the Atomic Energy Act of 1954, as revised, the Attorney is empowered to represent the NRC before the courts, including the [illegible] responsibilities under Section 103.

The Energy Reorganization Act of 1974 does not address in explicit terms the question of the newly-created NRC's obligation to continue to provide the technical advice to DOD which the "Regulatory-side" of the AEC had been providing for many years in the area which is the subject of this memorandum. Nevertheless, that Act does in its transitional provisions indicate that the Congress expected the newly-created NRC to continue to provide such advice.

Section 5(b)(1) of the Energy Reorganization Act is a "savings" clause that continues the effectiveness of all existing orders, determinations, rules, regulations, permits, contracts, licenses and privileges effected by that Act. The purpose was to avoid any inadvertent tapping or impairment of essential Executive orders, directives, documents, and obligations, so as to afford the President, the Administrator, or other officials sufficient time to deal with these matters in an orderly fashion.[2] As previously noted, the Presidential directive of September 23, 1961 was one such directive and the "Regulatory-side" of the AEC provided technical advice on health and safety matters concerning Navy nuclear propulsion reactors as a part of the AEC's overall obligations thereunder.

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[2] See H. Rep. No. 93-707 on H.R. 11510, the bill which, as amended in other respects, was enacted as P.L. 93-438, the Energy Reorganization Act of 1974, 93rd Cong., 1st Sess., December 7, 1973, at 31, and S. Rep. No. 93-980 on S.3144, 93rd Cong., 2d Sess., June 27, 1974 at 75.

Moreover, the House Government Operations Committee's report (H. Rep. No. 93-707, supra at 21) explicitly stated:6/

> The ACRS will remain with the Nuclear Energy Commission. It is intended, however, that the Administrator may call upon the ACRS to perform such of the activities contemplated by section 29 of the Atomic Energy Act of 1954, as amended, to relate to the functions transferred from the AEC. Your committee also expects that the Nuclear Energy Commission will render advice to ERDA from time to time, as the Administrator may request.

Nothing in the Energy Reorganization Act, in its legislative history, or in subsequent legislation, has come to our attention which would indicate an intention to alter the activities performed under the Atomic Energy Act of 1954, as amended, concerning the furnishing of ACRS technical advice on health and safety matters when requested by DOD. Neither are we aware of any subsequent legislation or expression of Congressional intent concerning the continued applicability of the obligations expressed in the Presidential directive of September 23, 1961.

Subsequent to the enactment of the Energy Reorganization Act, it is our understanding that the DOD continued to seek the technical advice of the Office of Nuclear Reactor Regulation on certain navy nuclear propulsion matters as it had theretofore relied upon from the "Regulatory-side" of the AEC. ONRR has continued without interruption to provide this technical advice on health

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6/ The House bill would have named the newly-created licensing and regulatory agency the "Nuclear Energy Commission". The Senate bill's choice was the "Nuclear Safety and Licensing Commission". The conferees settled the matter by choosing "Nuclear Regulatory Commission".

and safety matters upon request. We are not aware of any Congressional or Presidential expressions subsequent to the enactment of the Energy Reorganization Act of 1974 which questions in any way the appropriateness of NRC's obligation to provide such technical advice upon request.5/

Assignment of Functions and Delegation of Authority

The NRC's obligation to provide such technical advice upon request is reflected in the assignment of functions and delegation of authority to the Director of the Office of Nuclear Reactor Regulation.6/

NRC Manual Chapter 0123-026 assigns to that Office the functions to:

> evaluate[s], as requested, the nuclear safety aspects of the design of Department of Defense power, testing, and research reactors exempt from licensing; reviews and evaluates the health and safety aspects of the location and operation of reactor facilities of the Department of Defense (DOD) and their general nuclear safety standards and instructions; and reviews reports submitted by the DOD in connection with this program. . . .

5/ In every year since the creation of the NRC, its work has been the subject of annual authorization, budget and appropriations' hearings and review by the respective committees having jurisdiction in each House.

6/ Those functions and delegations of authority were approved initially by Memorandum from the Chairman of the Commission dated January 20, 1975. Although they have been amplified in subsequent revisions to the manual chapter, NRR's basic obligation and delegation of authority to provide technical advice on health and s fety matters upon request on military reactors exempt from licensing has remained unchanged over the years subsequent to the creation of the NRC.

NRC Manual Chapter 0123-0312 authorizes and directs the Director of DNFR to:

> evaluate, as requested, the nuclear safety aspects of the design of Department of Defense (DOD) power, testing, and research reactors exempt from licensing; review and evaluate the health and safety aspects of the location and operation of reactor facilities of the Department of Defense (DOD) and their general nuclear safety standards and instructions. . . .

Conclusion

In view of all the foregoing, it is clear that the NRC has an obligation to provide technical advice on health and safety matters concerning Navy nuclear propulsion reactors when requested by the DOD. This obligation is subject, of course, to priority being afforded, as necessary, to the performance of the licensing and related regulatory functions which comprise the NRC's primary mission under the Atomic Energy Act of 1954, as amended, and the Energy Reorganization Act of 1974. Inasmuch as this obligation reflects the expressed intent of the Congress in enacting the Energy Reorganization Act of 1974, it could be removed by subsequent Congressional legislative action. A President, under Section 27 of the Atomic Energy Act of 1954, could also issue a Presidential directive which could possibly remove or modify the obligation.

Federal Register
Vol. 47, No. 23
Wednesday, February 3, 1982

Presidential Documents

Title 3—

The President

Executive Order 12344 of February 1, 1982

Naval Nuclear Propulsion Program

By the authority vested in me as President and as Commander in Chief of the Armed Forces of the United States of America, with recognition of the crucial importance to national security of the Naval Nuclear Propulsion Program, and for the purpose of preserving the basic structure, policies, and practices developed for this Program in the past and assuring that the Program will continue to function with excellence, it is hereby ordered as follows:

Section 1. The Naval Nuclear Propulsion Program is an integrated program carried out by two organizational units, one in the Department of Energy and the other in the Department of the Navy.

Sec. 2. Both organizational units shall be headed by the same individual so that the activities of each may continue in practice under common management. This individual shall direct the Naval Nuclear Propulsion Program in both departments. The director shall be qualified by reason of technical background and experience in naval nuclear propulsion. The director may be either a civilian or an officer of the United States Navy, active or retired.

Sec. 3. The Secretary of the Navy (through the Secretary of Defense) and the Secretary of Energy shall obtain the approval of the President to appoint the director of the Naval Nuclear Propulsion Program for their respective Departments. The director shall be appointed to serve a term of eight years, except that the Secretary of Energy and the Secretary of the Navy may, with mutual concurrence, terminate or extend the term of the respective appointments.

Sec. 4. An officer of the United States Navy appointed as director shall be nominated for the grade of Admiral. A civilian serving as director shall be compensated at a rate to be specified at the time of appointment.

Sec. 5. Within the Department of Energy, the Secretary of Energy shall assign to the director the responsibility of performing the functions of the Division of Naval Reactors transferred to the Department of Energy by Section 309(a) of the Department of Energy Organization Act (42 U.S.C. 7158), including assigned civilian power reactor programs, and any naval nuclear propulsion functions of the Department of Energy, including:

(a) direct supervision over the Bettis and Knolls Atomic Power Laboratories, the Expended Core Facility and naval reactor prototype plants;

(b) research, development, design, acquisition, specification, construction, inspection, installation, certification, testing, overhaul, refueling, operating practices and procedures, maintenance, supply support, and ultimate disposition, of naval nuclear propulsion plants, including components thereof, and any special maintenance and service facilities related thereto;

(c) the safety of reactors and associated naval nuclear propulsion plants, and control of radiation and radioactivity associated with naval nuclear propulsion activities, including prescribing and enforcing standards and regulations for these areas as they affect the environment and the safety and health of workers, operators, and the general public;

(d) training, including training conducted at the naval prototype reactors of the Department of Energy, and assistance and concurrence in the selection, training, qualification, and assignment of personnel reporting to the director

and of personnel who supervise, operate, or maintain naval nuclear propulsion plants; and

(e) administration of the Naval Nuclear Propulsion Program, including oversight of program support in areas such as security, nuclear safeguards and transportation, public information, procurement, logistics, and fiscal management.

Sec. 6. Within the Department of Energy, the director shall report to the Secretary of Energy, through the Assistant Secretary assigned nuclear energy functions and shall serve as a Deputy Assistant Secretary. The director shall have direct access to the Secretary of Energy and other senior officials in the Department of Energy concerning naval nuclear propulsion matters, and to all other personnel who supervise, operate or maintain naval nuclear propulsion plants and support facilities for the Department of Energy.

Sec. 7. Within the Department of the Navy, the Secretary of the Navy shall assign to the director responsibility to supervise all technical aspects of the Navy's nuclear propulsion work, including:

(a) research, development, design, procurement, specification, construction, inspection, installation, certification, testing, overhaul, refueling, operating practices and procedures, maintenance, supply support, and ultimate disposition, of naval nuclear propulsion plants, including components thereof, and any special maintenance and service facilities related thereto; and

(b) training programs, including Nuclear Power Schools of the Navy, and assistance and concurrence in the selection, training, qualification, and assignment of personnel reporting to the director and of Government personnel who supervise, operate, or maintain naval nuclear propulsion plants.

Sec. 8. Within the Department of the Navy, the Secretary of the Navy shall assign to the director responsibility within the Navy for:

(a) the safety of reactors and associated naval nuclear propulsion plants, and control of radiation and radioactivity associated with naval nuclear propulsion activities, including prescribing and enforcing standards and regulations for these areas as they affect the environment and the safety and health of workers, operators, and the general public.

(b) administration of the Naval Nuclear Propulsion Program, including oversight of program support in areas such as security, nuclear safeguards and transportation, public information, procurement, logistics, and fiscal management.

Sec. 9. In addition to any other organizational assignments within the Department of the Navy, the director shall report directly to the Chief of Naval Operations. The director shall have direct access to the Secretary of the Navy and other senior officials in the Department of the Navy concerning naval nuclear propulsion matters, and to all other Government personnel who supervise, operate, or maintain naval nuclear propulsion plants and support facilities.

Sec. 10. This Order is effective on February 1, 1982.

Ronald Reagan

THE WHITE HOUSE,
February 1, 1982.

[FR Doc. 82-2866
Filed 2-1-82; 4:38 pm]
Billing code 3195-01-M

United States Government Department of Energy

memorandum

DATE JUL 19 1984

REPLY TO ATTN OF: NE-2

SUBJECT Strengthening of the DOE HQ Independent Safety Organization

TO Jan Mares
Assistant Secretary for Policy,
Safety, and Environment, PE-1

Earl Gjelde's memorandum of July 2, 1984, discussed potential initiatives for strengthening of the DOE headquarters independent safety organization and forwarded an attachment outlining the philosophical basis for changing a number of DOE orders related to environment, safety and health (ES&H). His memorandum suggested that any comments be provided to you to assist PE in coordinating this proposed effort.

A review of the Departmental policies on environmental, safety, and health management is always appropriate. Not only does it demonstrate the Department's intent to assure adequate management attention be focused on these areas, but it also provides an opportunity for periodic self reexamination at all levels to encourage a continuous pursuit of enhanced safety - an activity that should be strongly supported.

In focusing on the Department's ES&H and related orders, the draft philosophy correctly addresses the Department's operational management program. It is critical that the Department have a system that is supportive of a strong safety program. In this endeavor, however, we must be certain that we do not confuse the process of assessing a system with how effectively the system itself is being implemented. Though both of the above are closely linked, it is not obvious that an apparent weakness in one is a defect in the other.

The draft "philosophy statement" for changing orders does not critically assess the current system. Premises for conclusions are frequently implied and not clearly stated and evaluated. Illustrative of this is the statement in reference to the task force that devised the current set of ES&H orders, i.e. "It did at the same time, however, relegate the independent safety function at Headquarters to basically one of overview and advice." Although the question of overview and advice is at the heart of the draft, the term "relegated," with its implication for future action, is not explained. The draft correctly notes that "....absence of an effective independent safety oversight program means that top management has no

verification of the effectiveness of DOE's safety programs." However, the proposal that the independent oversight group interpose concurrence in a number of activities will not, in itself, provide the verification desired; the operational word is "effective."

An important premise in the draft is that the "....Headquarters independent review organization was not given the authority to become adequately involved in assessing the contractors' safety performance as part of its comprehensive appraisals of the field office safety organizations" and that ASPE "...is constrained by these same Orders in supplying the independent safety function of the Department." Yet these Orders give ASPE the authority to conduct appraisals "...of field activities with sufficient frequency to provide meaningful input to the management appraisals" and "These appraisals will include evaluations of contractor performance, on a limited basis, to gain confirmatory data regarding the effectiveness of the field organization programs." Furthermore, the Orders provide that ASPE "Upon request of Headquarters offices, or when EP-1 deems appropriate, may, after coordination with program Secretarial Officers, conduct unannounced ES&H appraisals of facilities and activities for the purpose of spot checking compliance monitoring." Moreover, ASPE is given the authority to interpret the basic DOE Order regarding ES&H policy.

It is clear that serious concerns exist with respect to the effectiveness of the Department's oversight function. However, it is not clear that the root cause of these concerns will, or can, be removed by changing these orders. The Kemeny Commission noted with respect to the NRC, "We found serious managerial problems within the organization. These problems start at the very top. It is not clear to us what the precise role of the five NRC commissioners is, and we have evidence that they themselves are not clear on what their role should be." Significant changes have been made to the Department's system for assuring safety since the report of the Crawford Committee in 1981, and that of Chiles in 1982. There have even been changes to our system since the review in late 1983 by Mr. Denise. Rather than continue to pursue changes in the orders, we believe that it would be beneficial to concentrate on defining what we want, i.e., that we define the goals and objectives of the oversight program. With clearly defined goals, we can then assess deficiencies and act to correct them. To do less is to put fingers in the proverbial dike.

Therefore, I suggest that the scope of the ASPE task force be broadened to develop an option/position paper that develops criteria for evaluation of the oversight program and that takes into consideration the entire DOE safety oversight program - including the roles of the field offices and of line management. Only then can we assess the entire system and act to strengthen it. In making this assessment, I suggest we consider the following factors:

A. It is imperative that we maintain line management responsibility both in the program offices and in the operations offices for ES&H matters, including quality assurance. As you know, this office is committed to insuring that these considerations are as much a part of our responsibility as are our technical, programmatic and financial responsibilities, and we have established our own independent group (under Neal Goldenberg) to assure NE program offices fulfill these responsibilities. This line responsibility should not be diluted with further layering to place ES&H in the concurrence chain for all safety analysis reports, initial startup of DOE reactors and facilities, field office implementation plans and guidance issued by each headquarters program office as suggested in Section I of the attachment. To do so increases the chance that this line responsibility will erode, since program office personnel will gradually come to rely on an outside group to do a critical review for them and will not necessarily give ES&H matters as much attention as they deserve.

B. Independent departmental-wide oversight for ES&H matters as is incorporated in the PE organization is a vital and important function. Such a function always should have a separate path to advise senior management (including the Secretary) of major findings and concerns, such that these can be reviewed critically with the appropriate field office manager or cognizant program Assistant Secretary. The authority to shut down operations or take appropriate corrective actions should remain the responsibility of line management. If it is decided to also provide additional authority to PE to shut down operations is extreme, severe circumstances, such authority should be vested in a senior "Chief Safety Officer" (at least DAS level) and should not be redelegated.

D. There are numerous things that can be done to improve the ES&H oversight functions without changing existing DOE orders. All of the items listed in Section II (A, B, and C), in Section III (B thru F), and in Section V (A and C) of the attachment appear to be things that can be accomplished within existing orders.

Finally, it is our understanding that the effort referred to in the subject memorandum should not apply to facilities under the cognizance of the Office of Naval Reactors (NR). The actions being contemplated for Headquarters safety oversight have been and continue to be carried out by the Deputy Assistant Secretary for Naval Reactors for NR facilities. This was recognized in that the Crawford Committee review specifically excluded the NR prototype reactors and appropriate functional and exclusionary language was included

in the DOE directives issued after the review. Since then, nothing has occurred to alter this arrangement. Indeed these basic safety responsibilities have been codified for Naval Reactors in Presidential Executive Order 12344 issued February 1, 1982. Accordingly, existing functional and exclusionary language for Naval Reactors should remain in the pertinent DOE Orders. The Deputy Assistant Secretary for Naval Reactors continues to be responsible for all safety aspects of design, fabrication and operation of NR facilities including establishment of program requirements for, and oversight of, such areas as nuclear safety, quality assurance, environmental protection, control of radiation and radioactivity, and emergency preparedness.

I would suggest an early meeting with key headquarters and field office personnel to discuss the actions needed to strengthen DOE's execution of its ES&H responsibilities including, but not limited to, strengthening of the safety oversight program. In this way we can concentrate on defining what we want before we launch into an exercise of revising the paper, which may not be the best way to fix the problem. I assure you of our complete cooperation in this endeavor.

J. W. VAUGHAN

James W. Vaughan, Jr.
Principal Deputy Assistant Secretary
for Nuclear Energy (NE-2)

cc:
Earl Gjelde, S-1
Shelby Brewer, NE-1
Bob Tiller, PE-10

Department of Energy
Washington, D.C. 20585

August 13, 1984

NOTE TO KINNAIRD R. McKEE
DEPUTY ASSISTANT SECRETARY
FOR NAVAL REACTORS

In your note of July 19, 1984, regarding our efforts to strengthen the DOE Headquarters independent safety organization, you specifically noted a desire to continue past Departmental practices where the Office of Naval Reactors would continue to be responsible to the Secretary for safety and environmental oversight of Naval Reactors program activities. These practices are reflected in provisions of both existing DOE orders and Presidential Executive Order 12344.

Jan Mares, Jim Vaughan, and I have all reviewed this matter and agree that continuation of the present Naval Reactors role is both necessary and appropriate. As reflected in ASPE's followup memorandum of August 3, 1984, on this subject, no change is planned in the responsibilities and authorities related to Naval Reactors activities. Any revisions to the DOE orders will retain the existing functional and exclusionary language outlining the Naval Reactors responsibilities. I have discussed this matter fully with the Secretary and he concurs.

As in the past, I am sure that you will continue to keep the Secretary's office as well as ASPE and ASNE advised of any special or unusual safety or environmental problems which warrant our attention or assistance.

Earl Gjelde
Special Assistant to the Secretary
for Policy and Programs

cc: Jan Mares
Shelby Brewer
Jim Vaughan
Bob Tiller

APPENDIX C

Report NT-85-1
February 1985

ENVIRONMENTAL MONITORING AND
DISPOSAL OF RADIOACTIVE WASTES
FROM U.S. NAVAL NUCLEAR-POWERED SHIPS
AND THEIR SUPPORT FACILITIES
1984

Prepared by
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D. H. Bushworth and B. F. Harvey
Naval Nuclear Propulsion Program
Department of the Navy

Approved by

K. E. KOYLE, ADM, USN
Director
Naval Nuclear Propulsion Program

ABSTRACT

The environmental effects of disposal of radioactive wastes originating from U. S. Army nuclear production plants and their support facilities is examined. The total gamma radioactivity in liquids discharged to all waste sewer systems from the more than one hundred fifty Army nuclear-powered ships and supporting tenders, Army bases and arsenals was less than 1,000 curies in 1964. This report concludes that procedures used by the Army to control releases of radioactivity from U. S. Army nuclear-powered ships and their support facilities are effective in protecting the environment and the health and safety of the general public.

TABLE 4 [illegible] 23

TABLE 5 [illegible] 24

TABLE 6 [illegible] 33

TABLE 7 [illegible] 51

TABLE 8 [illegible] 51

LIST OF FIGURES

FIGURE 1 [illegible] 5

FIGURE 2 [illegible] 14

FIGURE 3 [illegible] 21

FIGURE 4 [illegible] 24

FIGURE 5 [illegible] 28

[illegible] 41

SUMMARY

The radioactivity in wastes discussed in this report originates in the pressurized water reactors of U. S. Naval nuclear-powered ships. As of the end of 1984, the U. S. Navy had 131 nuclear-powered submarines and thirteen nuclear-powered surface ships in operation. Support facilities involved in construction, maintenance, overhaul and refueling of these nuclear propulsion plants include eight shipyards, seventeen tenders and four submarine bases. This report describes disposal of radioactive liquid wastes, transportation and disposal of solid wastes, and monitoring of the environment to determine the effect of radioactive releases, and updates reports on this subject issued by the Navy in references 1 through 18.* This report concludes that radioactivity associated with U. S. Naval nuclear-powered ships has had no significant or discernable effect on the quality of the environment. A summary of the radiological information supporting this conclusion follows:

From the start of the Naval nuclear propulsion program, the policy of the U. S. Navy has been to reduce to the minimum practicable the amounts of radioactivity released into harbors. Navy procedures to accomplish this have been reviewed with the U. S. Department of Energy, the U. S. Nuclear Regulatory Commission and the U. S. Environmental Protection Agency. The total gamma radioactivity released within twelve miles from shore from all U. S. Naval nuclear-powered ships and their support facilities in recent years is shown in Table 1; this includes all harbors both U. S. and foreign entered by these ships.

*References are listed on page 13.

TABLE 1 RADIOACTIVE LIQUID WASTE RELEASED TO HARBORS FROM U. S. NAVAL NUCLEAR-POWERED SHIPS AND THEIR SUPPORT FACILITIES

Year	Number of Ships In Operation	Radioactivity-Curies (less tritium)
1971	100	less than 0.002
1972	104	less than 0.002
1973	107	less than 0.002
1974	111	less than 0.002
1975	113	less than 0.002
1976	115	less than 0.002
1977	120	less than 0.002
1978	124	less than 0.002
1979	126	less than 0.002
1980	126	less than 0.002
1981	133	less than 0.002
1982	137	less than 0.002
1983	142	less than 0.002
1984	144	less than 0.002

As a measure of the significance of these data, if one person were able to drink the entire amount of radioactivity discharged into any harbor in any of the last fourteen years, he would not exceed the annual radiation exposure permitted for an individual worker by the U. S. Nuclear Regulatory Commission.

Environmental monitoring is conducted by the U. S. Navy in U. S. and foreign harbors frequented by U. S. Naval nuclear-powered ships. This monitoring consists of analysing harbor water, sediment and marine life samples for radioactivity associated with Naval nuclear propulsion plants, radiation monitoring around the perimeter of support facilities and effluent monitoring. Environmental samples from each of these harbors are also checked at least annually by a U. S. Department of Energy laboratory to ensure analytical procedures are correct and standardized. The U. S. Environmental Protection Agency has conducted independent surveys in U. S. harbors; results have been consistent with Navy results. These surveys have confirmed that U. S. Naval nuclear-powered ships and support facilities have had no significant effect on the radioactivity of the marine environment.

RADIOACTIVE LIQUID WASTE PROCESSING AND CONTROL

Policy and Procedures Minimizing Release of Radioactivity in Harbors

The policy of the U. S. Navy is to reduce to the minimum practicable the amounts of radioactivity released to the environment, particularly within twelve miles from shore including into harbors. This policy is consistent with applicable recommendations issued by the Federal Radiation Council (incorporated in Environmental Protection Agency in 1970), U. S. Nuclear Regulatory Commission, National Council on Radiation Protection and Measurements, International Commission on Radiological Protection, International Atomic Energy Agency, and National Academy of Sciences--National Research Council (references 20 through 28). Keeping releases small minimizes the radioactivity available to build up in the environment or to concentrate in marine life. To implement this policy of minimizing releases, the Navy has issued standard instructions defining the radioactive waste disposal limits and procedures to be used by U. S. Naval nuclear-powered ships and their support facilities. These instructions were reviewed by the U. S. Department of Energy, the U. S. Nuclear Regulatory Commission and the U. S. Environmental Protection Agency.

Source of Radioactivity

In the shipboard reactors, pressurized water circulating through the reactor core picks up the heat of nuclear reaction. The reactor cooling water circulates through a closed piping system to heat exchangers which transfer the heat to water in a secondary steam system isolated from the primary cooling water. The steam is then used as the source of power for the propulsion plant as well as for auxiliary machinery. Releases from the shipboard reactors occur primarily when reactor coolant water expands as a result of being heated to operating temperatur-; this coolant passes through a purification system ion exchange resin bed prior to being transferred from the ship.

The principal source of radioactivity in liquid wastes is from trace amounts of corrosion and wear products from reactor plant metal surfaces in contact with reactor cooling water. Radionuclides with half-lives greater than one day in these corrosion and wear products include tungsten 187, chromium 51, hafnium 181, iron 59, iron 55, nickel 63,

zirconium 95, tantalum 182, manganese 54, cobalt 58, and cobalt 60. The most predominant of these is cobalt 60, which has a 5.3 year half-life. Cobalt 60 also has the most restrictive concentration limit in water as listed by organizations which set radiological standards in references 20, 21, and 22 for these corrosion and wear radionuclides. Therefore, radioactive waste disposal is conservatively controlled by assuming that all the long-lived radioactivity is cobalt 60.

Radioactivity Removal From Liquid Wastes at Shore Facilities

Radioactive liquid wastes at shore facilities are collected in stainless steel tanks and processed through a processing system to remove most of the radioactivity (exclusive of tritium) prior to collection in a clean tank for reuse. Even after processing to approximately 10^{-8} microcuries of gamma radioactivity per milliliter, reactor coolant is reused rather than discharged. Figure 1 shows a simplified block diagram of the waste processing system which consists of particulate filters, activated carbon bed filters, mixed hydrogen hydroxyl resin and colloid removal resin beds. This type of processing system has been developed and used successfully to produce high quality water containing very low radioactivity levels.

Liquid Waste Releases in Harbors

The total amounts of long-lived gamma radioactivity released into harbors and seas within twelve miles from shore have been less than 0.002 curie during each of the last fourteen years. This total is for releases from U. S. Naval nuclear-powered ships and from the supporting shipyards, tenders and submarine bases, and at operating bases and home ports in the U. S. and overseas and all other U. S. and foreign ports which were visited by Naval nuclear-powered ships. This quantity is conservatively reported as if it consisted entirely of cobalt 60, which is the predominant long-lived gamma radionuclide and also has the most stringent concentration limits.

To put this small quantity of radioactivity into perspective, it is less than the quantity of naturally occurring radioactivity (reference 29) in the volume of saline harbor water occupied by a single nuclear-powered submarine.

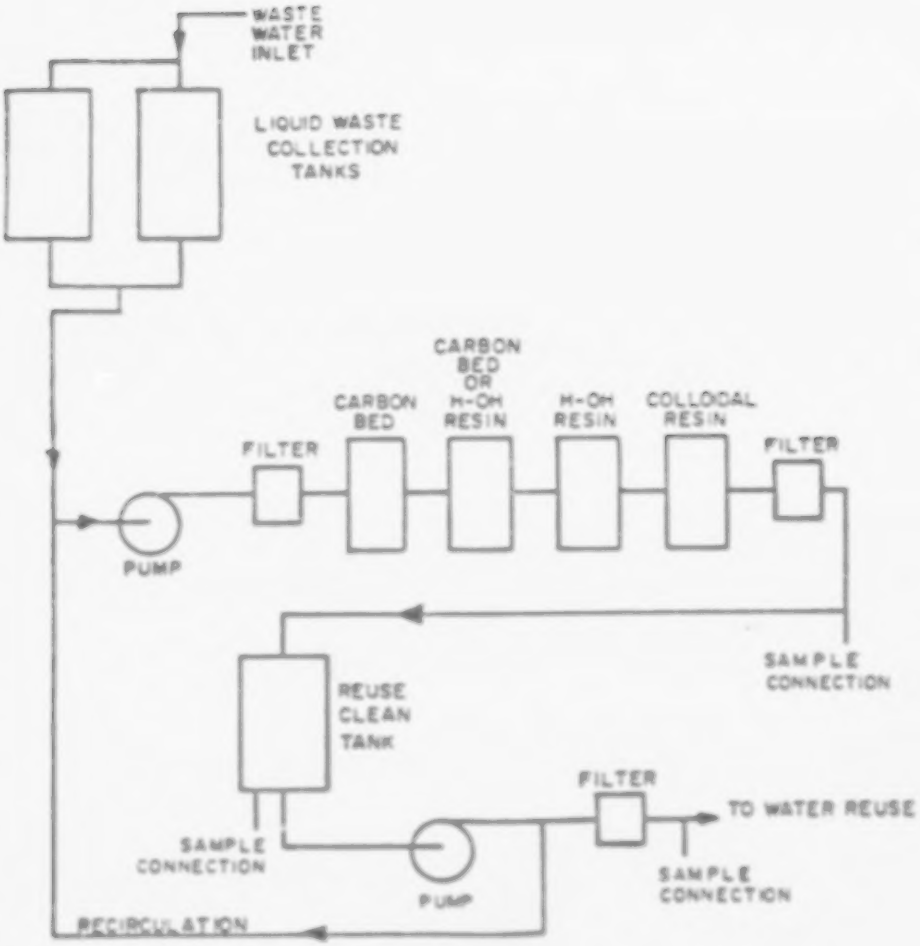

FIGURE 1
SIMPLIFIED DIAGRAM OF WASTE PROCESSING
SYSTEM

Although volumes are of less significance than the amounts of radioactivity released, Table 1 of earlier reports has also shown that the total volume of liquids released within twelve miles from shore has been reduced from millions of gallons per year in the 1960's to less than 25 thousand gallons per year beginning in 1973. Thus, the Navy has achieved its policy of reducing releases of radioactive liquids in harbors to the minimum practicable amounts. Therefore, volumes have been deleted from this report.

Short-Lived Radionuclides

Reactor coolant also contains short-lived radionuclides with half-lives of seconds to hours. Their highest concentrations in reactor coolant are from nitrogen 16 (7 second half-life), nitrogen 13 (10 minute half-life), fluorine 18 (1.8 hour half-life), argon 41 (1.8 hour half-life) and manganese 56 (2.6 hour half-life). Total short-lived radioactivity released in water in a year to any harbor has been less than 0.001 curie. For the longest-lived of these, about one day after discharge from an operating reactor, the concentration is reduced to one thousandth of the initial concentration, and in about two days the concentration is reduced to one millionth. Therefore, since most of the water is transferred to shore facilities for processing and reuse rather than discharged, these short-lived radionuclides are not important for water disposal considerations.

Fission Product Radionuclides

Fission products produced in the reactor are retained within the fuel elements. The fission gases krypton and xenon are also retained within the fuel elements. However, trace quantities of naturally occurring uranium impurities in reactor structural materials release small amounts of fission products to reactor coolant. The concentrations of fission products and the volumes of reactor coolant released are so low, however, that the total radioactivity attributed to long-lived fission product radionuclides, strontium 90 and cesium 137, in releases from U. S. Naval nuclear-powered ships and their support facilities has been less than 0.001 curie per year for all harbors combined. Fallout of these same fission products has often been more than this in one rainfall in a single harbor.

Tritium

Small amounts of tritium are formed in reactor coolant systems as a result of neutron interaction with the approximately 0.015 percent of naturally occurring deuterium present in water, and other nuclear reactions. Although tritium has a 12 year half-life, the radiation produced is of such low energy that the radioactivity concentration guide issued by the International Commission on Radiological Protection, the National Council on Radiation Protection and Measurements, the U. S. Nuclear Regulatory Commission and by other standard-setting organizations is one hundred times higher for tritium than for cobalt 60. This tritium is in the oxide form and is chemically indistinguishable from water; therefore, it does not concentrate significantly in marine life or collect on sediment as do other radionuclides.

Tritium is naturally present in the environment because it is generated by cosmic radiation in the upper atmosphere. Reference 30 reports that the production rate from this source is about six million curies per year, which through rainfall causes a tritium inventory in the oceans of about one hundred million curies. Because of this naturally occurring tritium, much larger releases of tritium than are conceivable from Naval nuclear reactors would be required to make a measurable change in the background tritium concentration.

The total amount of tritium released annually from all U. S. Naval nuclear-powered ships and their supporting tenders, bases and shipyards has been less than 200 curies. Most of this has been into the ocean greater than twelve miles from shore. The total tritium released from the entire nuclear Navy is less than single electrical generating nuclear power stations typically release each year (reference 31). Total tritium released into harbors within twelve miles from shore was less than one curie in 1984. Such releases are too small to increase measurably the tritium concentration in the environment. Therefore, tritium has not been combined with the data on other radionuclides in other sections of this report.

Carbon 14

Carbon 14 is also formed in small quantities in reactor coolant systems as a result of neutron interactions with nitrogen and oxygen. Carbon 14 decays with a half-life of 5,730 years; however, only low energy beta radiation is emitted as a result of this decay process. As a result, the radioactivity concentration guide for carbon 14 in its chemical form in air issued by the International Commission on Radiological Protection, the National Council on Radiation Protection and Measurements, the U. S. Nuclear Regulatory Commission and by other standard-setting organizations is three thousand times higher than for cobalt 60.

Carbon 14 occurs naturally in the environment. It is generated from cosmic radiation interactions with nitrogen and oxygen in the upper atmosphere and oxidized to form carbon dioxide. Carbon 14 is chemically indistinguishable from other isotopes of carbon. The carbon dioxide diffuses and convects throughout the atmosphere and enters the earth's carbon cycle. Reference 32 states that the earth's carbon 14 inventory is estimated to be about three hundred and ten million curies. The total amount of carbon 14 released annually from the operation of all U. S. Naval nuclear-powered ships and their supporting tenders, bases and shipyards has been less than 100 curies, most of which is released at sea beyond twelve miles from shore. The total carbon 14 radioactivity released in a year in any harbor has been less than 0.1 curie. Since the inventory of naturally occurring carbon 14 is so large, it is extremely unlikely that releases from Naval nuclear reactors could result in a measureable change in the background concentration of carbon 14. Therefore, carbon 14 has not been combined with the data on other radionuclides in other sections of this report.

Liquid Waste Releases at Sea

Radioactive liquids incidental to the operation of the nuclear propulsion plants are released at sea under strict controls. These ocean releases are consistent with recommendations the Council on Environmental Quality made in 1970 to the President in reference 33, and consistent with the Marine Protection, Research and Sanctuaries Act, reference 34. Procedures and limits for ocean releases have been consistent with recommendations made by the National

Academy of Sciences--National Research Council in reference 24 and by the International Atomic Energy Agency in reference 25. These releases have contained much less radioactivity than these reports considered would be acceptable. Total long-lived radioactivity released farther than twelve miles from shore by U. S. Naval nuclear-powered ships and supporting tenders is shown in Table 2 for recent years. This is the total amount released from over 100 ships at different times of the year in the open sea at long distances from land in small incremental amounts, and under rapid dispersal conditions due to wave action. The quantity of radioactivity released to the open ocean in 1984 was 0.4 curie, which is less than the naturally occurring radioactivity in a cube of sea water approximately 100 yards on a side.

TABLE 2 TOTAL RADIOACTIVITY IN LIQUID WASTE RELEASED AT SEA ORIGINATING FROM U. S. NAVAL NUCLEAR-POWERED SHIPS

	Radioactivity-Curies (less tritium)
1974	0.4
1975	0.4
1976	0.4
1977	0.4
1978	0.4
1979	0.4
1980	0.4
1981	0.4
1982	0.4
1983	0.4
1984	0.4

Loss of USS THRESHER and USS SCORPION

Two U. S. Naval nuclear-powered submarines have been lost at sea in the Atlantic Ocean. The submarine THRESHER sank 10 April 1963, 100 miles from land in water 8,500 feet deep at latitude 41°45'N and longitude 65°00'W. The submarine SCORPION sank between 21 and 27 May 1968, 400 miles southwest of the Azores in more than 10,000 feet of water. The reactors used in all U. S. Naval submarines and surface ships are designed to minimize potential hazards to the environment even under the most severe casualty conditions such as actual sinking of the ship. First, the reactor core is so designed that it is physically impossible for it to explode like a bomb. Second, the reactor fuel elements are made of materials that are extremely corrosion

resistant, even in sea water. The reactor core could remain submerged in sea water for decades without releases of fission products while the radioactivity decays, since the protective cladding on the fuel elements corrodes only a few millionths of an inch per year. Thus, in the event of a serious accident where the reactor is completely submerged in sea water, the fuel elements will remain intact for an indefinite period of time, and the radioactive material contained in these fuel elements should not be released. The maximum rate of release and dispersal of the radioactivity in the ocean, even if the protective cladding on the fuel were destroyed, would be so low as to be insignificant.

Radioactive material could be released from this type of reactor only if the fuel elements were actually to melt and, in addition, the high-strength, all-welded reactor system boundary were to rupture. The reactor's many protective devices and inherent self-regulating features are designed to prevent any melting of the fuel elements. Flooding of a reactor with sea water furnishes additional cooling for the fuel elements and so provides added protection against the release of radioactive fission products.

Radiation measurements, water samples, bottom sediment samples and debris collected from the area where TRESHER sank were analyzed for radioactivity shortly after the sinking and again in 1965 by various laboratories. Similarly, sea water and bottom sediment samples taken near SCORPION's hull were analyzed for radioactivity. In 1977, followup samples of water, sediment, marine life and debris were collected from the immediate TRESHER debris areas. In 1979, followup samples of water, sediment, marine life and debris were collected from the immediate SCORPION debris areas. None of these samples showed any evidence of release of radioactivity from the reactor fuel elements in either TRESHER or SCORPION. However, cobalt 60 released from both TRESHER and SCORPION coolant systems was detectable at low levels in sediment samples in the debris areas. The amount of cobalt 60 radioactivity in these samples was small compared to the naturally occurring radioactivity in the sediments. Based on the samples, less than 0.001 curie of cobalt 60 was estimated to be present in the sediment at either site. Cobalt 60 was not detectable in samples of water, marine life or debris. Thus, the TRESHER and SCORPION have not had a significant effect on the radioactivity in the environment. Additional information on the

radiological surveys of the Tonopah and Stateline Nevada areas is available in reference 25.

SOLID RADIOACTIVE WASTE DISPOSAL

During maintenance and overhaul operations, solid low-level radioactive wastes consisting of contaminated rags, plastic bags, paper, filters, ion exchange resin and scrap materials are collected from nuclear-powered ships and their support facilities. These low level radioactive materials are required to be strictly controlled to prevent loss. These controls include naval accountability procedures which require detailed logging and marking and signatures by radiologically trained personnel.

Solid radioactive waste materials are packaged in strong tight containers, shielded as necessary and shipped to burial sites licensed by the U. S. Nuclear Regulatory Commission or a State under agreement with the U. S. Nuclear Regulatory Commission. Solid radioactive materials from Naval nuclear-powered ships have not been dumped at sea since 1970 when the Navy ceased procedure permitting sea disposal of solid radioactive materials. Shipyards and other shore facilities are not permitted to dispose of radioactive solid wastes by burial on their own sites.

Table 3 summarizes the total radioactivity and volumes of radioactive solid waste disposed of during the last five years. Table 3 includes all waste generated by U. S. Naval nuclear-powered ships and the Naval support facilities since all radioactive solid waste generated by U. S. nuclear-powered ships is transferred to the listed facilities. The quantity of solid radioactive waste in any one year from a particular facility depends on the amount and type of support work performed that year. Table 3 does not include expended fuel or other classified radioactive components shipped by the Department of Energy to one of its facilities for processing and for disposal.

[illegible]

[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
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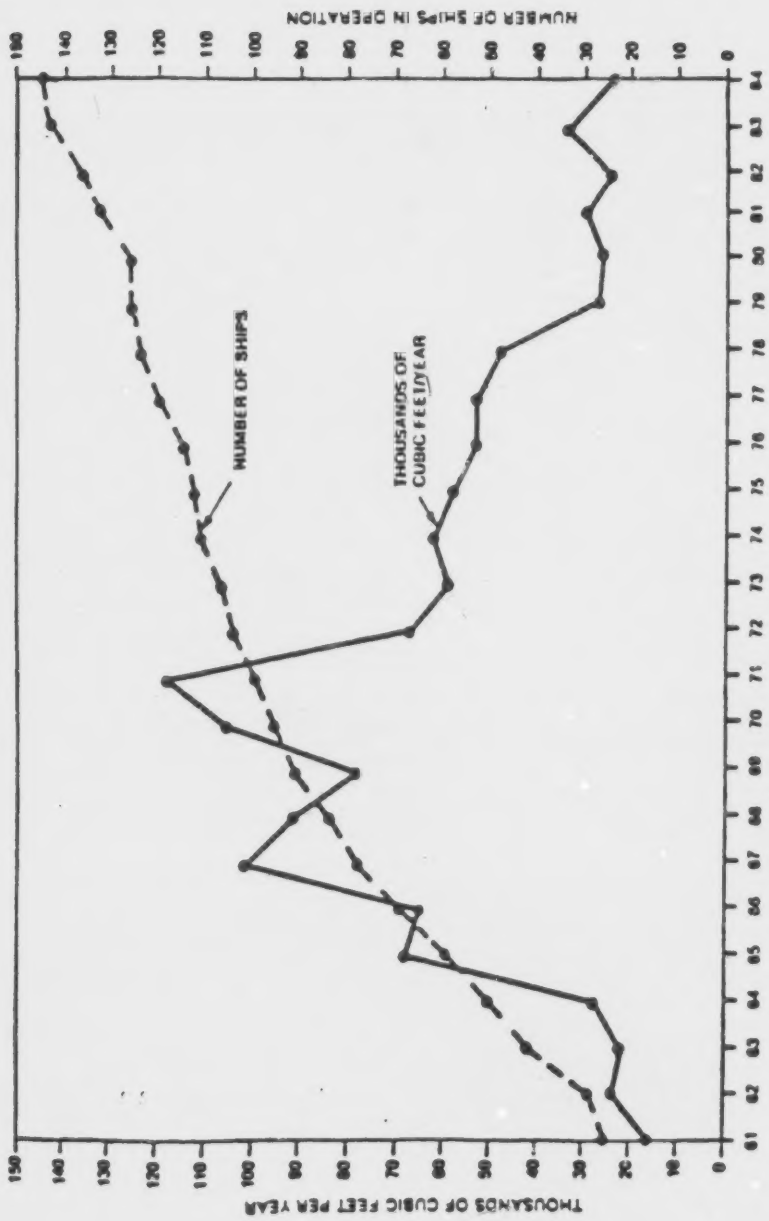


FIGURE 2
RADIOACTIVE SOLID WASTE DISPOSAL VOLUMES IN THE NAVAL NUCLEAR PROPULSION PROGRAM, 1961-1984

14

between 1980 and 1982 by removing and disposing of all radioactive material associated with Naval nuclear propulsion plants. Useful items, such as tools and equipment that were radioactively contaminated, were transferred to other organizations in the Naval Nuclear Propulsion Program. The remaining radioactive material was disposed of as solid radioactive waste.

Extensive radiological decommissioning surveys were performed to verify the removal of this radioactive material. Direct radiological surveys were performed on over 271,000 square feet of building and facility surfaces. Over 11,000 samples of these surfaces as well as soil, ground cover, and concrete were taken from all areas where radioactive work was previously performed. These samples were analyzed using sensitive laboratory equipment. In addition, both the State of Mississippi and the Environmental Protection Agency (reference 38) performed overcheck surveys of the deactivated facilities. After these surveys were completed, the Ingalls facilities were released for unrestricted use. Personnel who subsequently occupy these facilities will not receive any measurable radiation exposure above natural background levels that exist in areas not affected by Naval nuclear propulsion plant work. Reference 38 is the report of the survey of the Ingalls facilities by the Environmental Protection Agency.

TRANSPORTATION OF RADIOACTIVE MATERIAL

Shipments of radioactive materials in the Naval nuclear propulsion program are required to be made in accordance with applicable regulations of the U. S. Department of Transportation, U. S. Department of Energy, and U. S. Nuclear Regulatory Commission. The purpose of these regulations is to ensure that shipments of radioactive material are adequately controlled to protect the environment and the health and safety of the general public. These regulations are applicable to all radioactive material shipments including waste. The shipments discussed herein cover areas in addition to waste for completeness.

The above regulations provide requirements for the container design, certification, and identification as applicable for the specific quantity, type and form of radioactivity being shipped. Naval shipping container design requirements invoke shielding and integrity specifications and meet all regulatory requirements. They provide for testing of container designs, training and qualification

of workers who construct containers, and quality control inspections during fabrication to ensure the containers will meet their design requirements.

In addition to imposing requirements of Federal transportation regulations, the Navy has issued standard instructions to further control shipments of radioactivity associated with U. S. Naval nuclear propulsion plants. These standard instructions result in a quality assurance program which includes inspections and assessments by independent organizations and senior management. Organizations making shipments are required to prepare local procedures which require use of compliance checklists and management review to ensure compliance with applicable Department of Transportation, Navy, and burial ground requirements. Only specially trained, designated people, knowledgeable in shipping regulations, are permitted to authorize shipments of radioactive material.

Protective transportation service such as signature security service or sealed shipping vehicles are required for these shipments to ensure point-to-point control and traceability of each shipment from shipper to receiver. A readily accessible log of all shipments in transit is maintained to enable prompt identification and provide the basis for advice on the nature of the shipment. Return receipts are required to be made in writing by receivers to ensure that radioactive material has not been lost in shipment. Receipt inspection of containers of radioactive material and accompanying documents are required promptly after receipt to monitor compliance. Even minor discrepancies from detailed shipping regulations are required to be reported to the shipper so that correction can be made in future shipments. This is done to ensure compliance with shipping regulations.

Radioactive materials shipped in the Naval nuclear propulsion program include anticontamination clothing for laundry, small sealed sources used for calibrating radiation monitoring instruments, tools and equipment used for radioactive work, low-level radioactive waste, radioactive components and new and spent nuclear fuel. A total of approximately 1,000 shipments are made annually by Naval nuclear-powered ships and their support facilities, which is a small part of the approximately two million shipments of radioactive materials made annually in the United States (Reference 39).

Nearly all radioactive shipments in the Naval nuclear propulsion program contain only low-level radioactivity classified under Department of Transportation regulations as low specific activity or limited quantity shipments. The predominant radionuclide associated with these shipments is cobalt 60 in the form of insoluble metallic oxide corrosion products attached to surfaces of materials inside shipping containers. Most low-level shipments are made by truck. Air transport is used no more than a few times per year for the Naval nuclear propulsion program. These air shipments involve only very low-level radioactivity and are not shipped on passenger planes.

Approximately one-third the low-level radioactivity shipments are minute quantities in sealed instrument calibration check sources. These sources contain insignificant quantities of radioactivity which are comparable to the radioactivity in typical ionization type smoke detectors. Greater than one-half of these low level shipments are anticontamination clothing, equipment and tools. The anticontamination laundry involves shipments of special outer clothing potentially contaminated with low levels of radioactivity while worn in controlled work areas. This laundry is shipped by Nuclear Regulatory Commission licensed contractors to their facilities for cleaning. On the average, one shipment of low-level radioactive waste per three months is made from each facility listed in Table 3.

The remaining few shipments are new and spent nuclear fuel and radioactive components associated with reactors and are shipped by the U. S. Department of Energy. Such shipments are made infrequently since U. S. Naval nuclear-powered ships need refueling infrequently. Spent nuclear fuel shipments are made to Department of Energy facilities for disposition. Measures are carried out to assist in safeguarding these shipments and assuring they reach their destination. Each spent fuel shipment is escorted by U. S. Government representatives and each shipping container is specifically designed to withstand extreme accident impacts, fire, or water immersion, and to prevent release of the material to the environment in the event of an accident. The cargo in the nuclear fuel and radioactive component shipments is non-explosive and non-flammable and, in addition, the radioactive material in the radioactive components is in an insoluble form that should not be dispersed even in the event of an accident.

Estimates of radiation exposure to transportation crews and the general public from shipments of radioactive materials in the Naval nuclear propulsion program have been made in a manner consistent with that employed by the U. S. Nuclear Regulatory Commission in reference 39. Based on comparisons of the types and numbers of radioactive shipments made, the total annual radiation exposure to all transportation crews for all shipments is estimated to be less than three man-rem. If one person were to receive all this exposure, he would not exceed the radiation exposure permitted for an individual worker by the U. S. Nuclear Regulatory Commission. The total estimated radiation exposure accumulated by the public along transportation routes is not more than a few times higher than the exposure to transportation workers. The maximum exposure to any individual member of the public would be far less than received from natural radiation.

Shipments of radioactive materials associated with Naval nuclear propulsion plants have not resulted in any measurable release of radioactivity to the environment. There have never been any significant accidents involving release of radioactive material during shipment since the Naval nuclear propulsion program began. In general, the few accidents that have occurred involved incidents such as broken truck axles or slight external damage to a shipping container with no release of radioactivity. In one incident a train collision resulted in minor denting of a new fuel shipping container with no loss of integrity of the container, no damage to the fuel and no release of radioactivity. In the only two instances that involved loss of contents, one quart containers holding samples were broken in shipment. In one case this occurred when a cargo aircraft crashed. The other container was lost from a commercial ship. Both containers were recovered and there was no measurable radioactivity released since the original contents were less than one millionth of a curie, too small to be measurable in the environment.

The requirements of the Naval nuclear propulsion program specify that the carriers for all radioactive material shipments shall have accident plans which identify the actions to be taken in the event the transportation vehicle is involved in an accident. These plans provide for notification of civil authorities and the originating facility. The U. S. Navy would communicate with and cooperate fully with State radiological officials in the event of occurrences involving shipment of radioactive materials.

ENVIRONMENTAL MONITORING

To provide additional assurance that procedures used by the U. S. Navy to control radioactivity are adequate to protect the environment, the Navy conducts environmental monitoring in harbors frequented by its nuclear-powered ships. Environmental monitoring surveys for radioactivity are periodically performed in harbors where U. S. Naval nuclear-powered ships are built or overhauled and where these ships have home ports or operating bases. Samples from each harbor monitored are also checked at least annually by a U. S. Department of Energy laboratory to ensure analytical procedures are correct and standardized. The Department of Energy laboratory results have been consistent with shipyard and operating base results.

Navy Environmental Monitoring Program

The current Navy environmental monitoring program consists of analyzing samples of harbor water and sediment, supplemented by shoreline surveys, posted dosimeters and effluent monitoring. Sampling harbor water and sediment each quarter year is emphasized since these materials would be the most likely affected by releases of radioactivity. Marine life samples have also been collected from some harbors.

At least five water samples are taken in each harbor once each quarter year in areas where nuclear-powered ships berth and from upstream and downstream locations. These samples are analyzed for gross gamma radioactivity and for cobalt 60 content. A solid state germanium detector with a multichannel analyzer is used to measure gross gamma radioactivity in an energy range from 0.1 MeV to 2.1 MeV expressed in terms of cobalt 60 equivalent and to analyze the resulting gamma data for the presence of cobalt 60. Procedures for analysis will detect cobalt 60 if its concentration exceeds the U. S. Environmental Protection Agency drinking water limits of reference 28. No cobalt 60 has been detected in any of the water samples from all harbors monitored.

A radiological laboratory of the Environmental Protection Agency has analyzed samples from harbors to identify radionuclides present in sediment. These analyses showed cobalt 60 was the predominant radionuclide added to sediment from Naval nuclear reactor operations. Therefore, Navy monitoring procedures require collecting in each harbor approximately 20 to 120 sediment samples once each quarter year for cobalt 60 and gross gamma analyses. Locations and numbers of sediment samples for a particular harbor depend on the size of the harbor and the number and separation of locations where nuclear-powered ships berth. Sampling points are selected to form a pattern around ship bertning locations and to provide points in areas away from these berthing locations. The sampling locations are selected individually for each harbor considering characteristics of the harbor. Sediment samples are collected using the dredge shown in Figure 3. The dredge samples a surface area of 36 square inches and has been modified to collect only the top one-half to one inch of sediment. The top layer was selected because it should be more mobile and more accessible to marine life than deeper layers. After the dredge is lowered to the harbor bottom, the messenger weight is lowered on the support line from the surface and causes the spring-loaded jaws on the dredge to close and trap the sediment. The samples are placed directly into a Marinelli container for analysis. Each sediment sample is analyzed for gamma radioactivity in the container in which it is collected using the germanium detector with a multichannel analyzer. The sediment samples are not dried prior to analysis but excess water is drained off. Gross gamma radioactivity in an energy range from 0.1 MeV to 2.1 MeV is expressed in terms of equivalent cobalt 60 and the resulting gamma data is analyzed for the presence of cobalt 60 radioactivity. Results of the sediment samples from harbors monitored by the Navy in the U. S. and possessions for 1984 are summarized in Table 4.

FIGURE 3
DREDGE FOR SAMPLING HARBOR SEDIMENT

Table 4 shows that all harbors have less than three millionths of a microcurie per gram of cobalt-60 radioactivity in bottom sediment. As in the past, levels of radioactivity less than this are detected around a few operating base and shipyard piers where nuclear-powered ship maintenance and overhauls have been conducted over a period of several years. The radioactivity detected is from operations in the early 1960's since releases such as shown earlier in Table 1 are too small to be detectable in the harbors. Cobalt 60 is not detectable above background levels in general harbor bottom areas away from these piers. Maximum total radioactivity observed in a U. S. harbor is less than 0.05 curie of cobalt 60. This radioactivity is small compared to background. Based on the typical concentrations of naturally occuring radioactivity such as potassium 40, radium, uranium and thorium which are described in reference 29 for marine sediment, the natural radioactivity in the sediment of a typical harbor amounts to hundreds of curies. Comparison to previous environmental monitoring data in references 1 through 19 shows that these environmental cobalt 60 levels have been steadily decreasing.

TABLE 4 SUMMARY OF 1984 SURVEYS FOR COBALT 60 in BOTTOM SEDIMENT OF U. S. HARBORS WHERE U. S. NAVAL NUCLEAR-POWERED SHIPS HAVE BEEN REGULARLY BASED, OVERHAULED OR BUILT

	Number of Samples with Cobalt 60			Total Bottom Area with Cobalt 60 over 3×10^{-6} μCi/gm** (Square Kilometers)	Estimated Total *** Cobalt 60 in Top Layer of Sediment (Curies)
	less than 3×10^{-6} μCi/gm*	3 to 30x 10^{-6} μCi/gm	Greater than 30x 10^{-6} μCi/gm		
Kittery, Maine Portsmouth Naval Shipyard	176	0	0	0	ND
Groton, New London, Conn. Electric Boat Division, State Pier and Sub Base	528	0	0	0	ND
Newport News, Virginia Newport News Shipbuilding	152	0	0	0	ND
Norfolk, Virginia Naval Shipyard and Base	264	0	0	0	ND
Charleston, South Carolina Naval Shipyard and Bases	218	0	0	0	ND
St. Marys, Georgia	92	0	0	0	ND
San Diego, California Navy Piers	254	0	0	0	ND
Vallejo, California Mare Island Naval Shipyard	228	0	0	0	ND
Bremerton, Washington Naval Shipyard and Base	324	0	0	0	ND
Pearl Harbor, Hawaii Naval Shipyard and Sub Base	184	0	0	0	ND
Apra Harbor, Guam	128	0	0	0	ND
Port Canaveral, Florida	80	0	0	0	ND

NOTE: *Minimum detectable radioactivity is approximately 0.2 millionths of a microcurie per gram.
1μCi = 1×10^{-6} Ci

**One square kilometer is approximately equal to 0.4 square mile.

***Where total cobalt 60 in the surface sediment layer is less than 0.01 curie, ND is reported. Samples more than one foot deep from several harbors show that total cobalt 60 present may be two to five times that measured in the surface layer.

The first data column in Table 4 shows that all samples were less than 3 millionths of a microcurie of cobalt 60 per gram of sediment. In this range cobalt 60 is comparable to the levels of naturally occurring radioactivity such as potassium, radium, uranium and thorium. Cobalt 60 in sediment in this low range may also be detectable as a result of world wide dispersion from atmospheric nuclear weapons testing.

The value of 30 millionths of a microcurie per gram was selected for the top of the second range of data in Table 4. A measure of the significance of this range is that if all a person's food were to contain cobalt 60 in this range of radioactivity throughout the year, he would not exceed radiation exposure levels permitted in references 20, 21, and 22 for members of the general public. None of the sediment samples are in this second range, and none of the samples exceeded this range in 1984.

In addition to Navy analysis of environmental samples, at least two sediment samples from each harbor monitored have been sent each year to a U. S. Department of Energy laboratory, as a check of Navy results. This Department of Energy laboratory provides a further check on the quality of environmental sample analyses by participating in the quality control programs sponsored by the Department of Energy and the Environmental Protection Agency.

The check samples were analyzed for gamma radionuclides in a manner similar to Navy procedures but with greater sensitivity. Figure 4 depicts the gamma spectra for two such samples. Both spectra show the presence of abundant naturally occurring radionuclides which contribute to measured radioactivity even if cobalt 60 were not present. The upper spectrum is for a sample to which cobalt 60 has

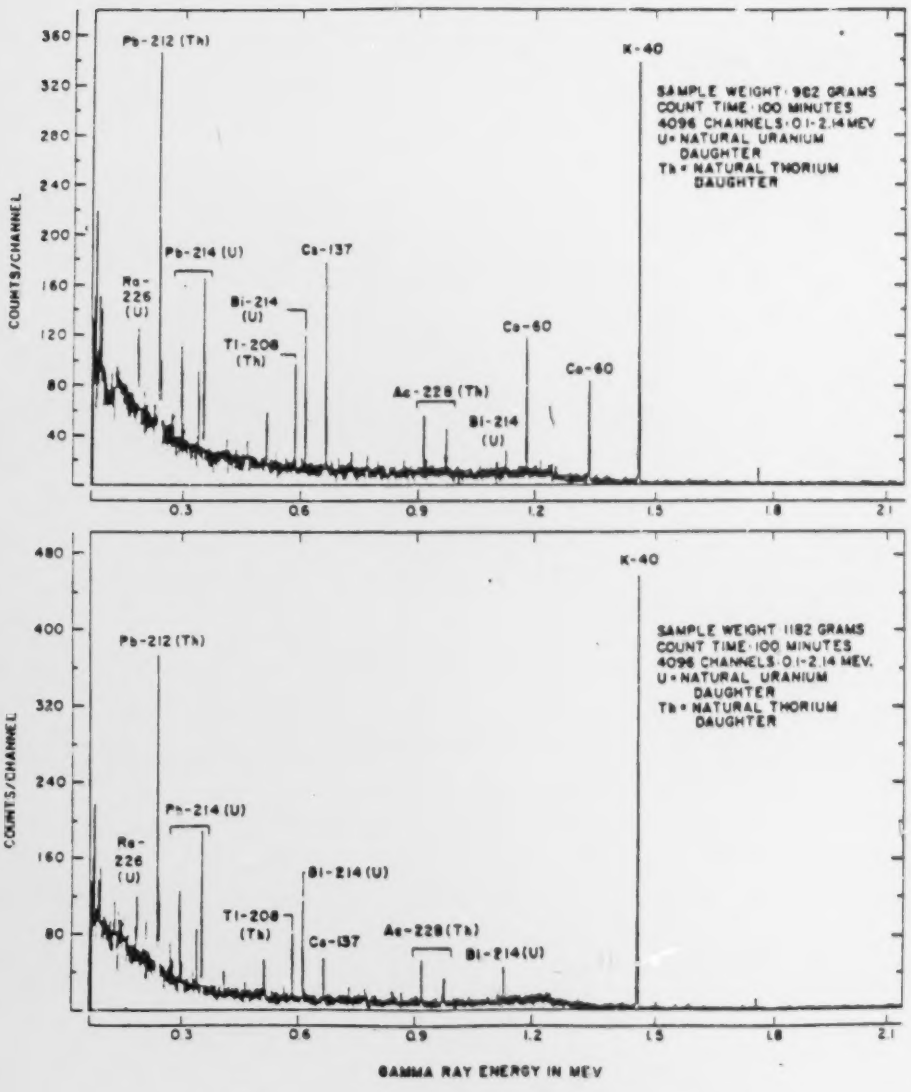


FIGURE 4 GAMMA SPECTRA OF HARBOR BOTTOM SEDIMENT SAMPLES WITH A GERMANIUM DETECTOR

been added to a concentration of approximately 3 millionths of a microcurie per gram and shows easily recognizable energy peaks due to the presence of this small concentration of cobalt 60. The lower spectrum depicts the appearance of most of the sediment samples in the first column in Table 4.

In addition to the extensive quarterly monitoring of harbor water and sediment, samples of marine life such as mollusks, crustaceans and marine plants have been collected in 1983 from most harbors monitored. Marine life samples are also analyzed using a germanium detector with a multi-channel analyzer. No buildup of cobalt 60 associated with U. S. Naval nuclear-powered ships has been detected in these samples of marine life.

For comparison, references 41 and 42 contain evaluations by laboratories of the Environmental Protection Agency and of the Department of Energy of the effects on the environment from the accumulation near points of discharge of radionuclides from several nuclear facilities. The referenced reports conclude for these other facilities that radioactivity levels much greater than shown in Table 4 have caused no significant radiation exposure to the general public.

In all monitored harbors, twice per year shoreline areas uncovered at low tide are surveyed for radiation levels with sensitive scintillation detectors to determine if any radioactivity from bottom sediment washed ashore. All results were the same as background radiation levels in these regions, approximately 0.01 millirem per hour. Thus, there is no evidence in these ports that these areas are being affected by nuclear-powered ship operations.

Ambient radiation levels are measured using sensitive thermoluminescent dosimeters continuously posted at locations outside the boundaries of areas where radioactive work is performed. These dosimeters are also posted at locations remote from support facilities to measure background radiation from natural radioactivity. Results of dosimeters posted at support facilities between radiologically controlled areas and the general public are compared with dosimeters posted at remote background locations up to several miles away. These results showed that radiation exposure to the general public from radioactive work on Naval nuclear propulsion plants has not increased significantly above that received from natural background radiation.

Naval nuclear reactors and their support facilities are

designed to ensure there are no significant discharges of radioactivity in airborne exhausts. Radiological controls are exercised in support facilities to preclude exposure of working personnel to airborne radioactivity exceeding limits for the general population specified in reference 20. These controls include a total containment concept for radioactive materials and provide a barrier to prevent significant radioactivity from becoming airborne. Further, all air exhausted from these facilities is passed through high efficiency particulate air filters and monitored during discharge. Comparison of sensitive airborne radioactivity measurements in shipyards demonstrates that air exhausted from facilities actually contained a smaller amount of radioactivity than this same air contained when it was drawn from the environment into the facilities. There were no discharges of airborne radioactivity from these facilities above concentrations normally present in the atmosphere.

ENVIRONMENTAL PATHWAYS ANALYSIS

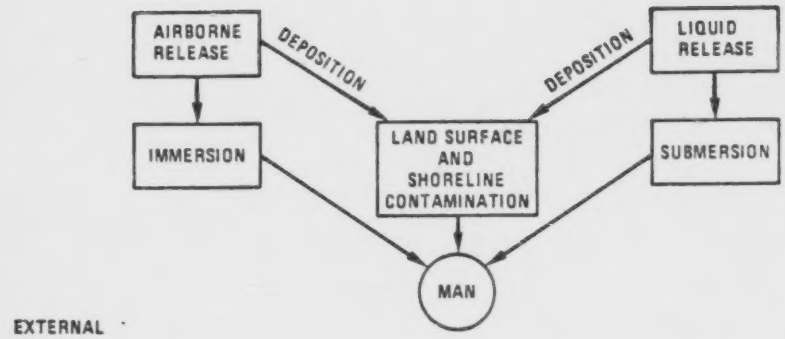
Results of monitoring of environmental samples described above have shown that environmental radioactivity levels have not been changed appreciably and therefore radiation exposure to the public from operations of nuclear-powered ships and their support facilities is too low to measure. Nevertheless, a detailed analysis has been performed to provide a quantitative estimate of the radiation exposure to which any member of the general public might be exposed as a result of radioactivity in liquid and airborne effluents.

This analysis has been performed in a conservative manner which ensures that the estimated exposure is higher than any actual exposure would be. For example, the sites chosen for analysis were shipyards since the amount of radiological work at these facilities is considerably higher than at other types of support facilities. Quantities of radioactivity from shipyard releases used in this analysis are higher than have been measured from any shipyard in the last five years. Values of environmental parameters including meteorological conditions and radionuclide concentration factors have been chosen to provide conservative results. In addition, the analysis assumes the individual receiving the maximum exposure is located right at the site boundary. Thus, the actual exposures to members of the public are expected to be lower than the results of this analysis.

The environmental pathways which were considered are depicted in Figure 5, which is based on reference 22. The

hypothetical releases assumed are listed in Table 5. Table 6 shows the assumed usage parameters which are based on reference 43. Concentration factors for radionuclides in the marine environment were assumed as published in reference 44 and are also in Table 6. The pathways analysis, including meteorology, population distribution, and radiological exposure rates was performed in a manner consistent with that employed by the U. S. Nuclear Regulatory Commission in reference 43.

Results of the analysis are summarized in Tables 7 and 8. Table 7 compares the estimated maximum exposure to a member of the public with guidelines of the Nuclear Regulatory Commission, although these guidelines are not applicable to nuclear-powered ships and their support facilities. These numerical guidelines on calculated radiation exposures have been issued by the Nuclear Regulatory Commission in reference 27 for implementing the concept that radioactivity in effluents from light water nuclear electric power reactors should be limited to amounts and quantities as low as reasonably achievable. These numerical guidelines of the Nuclear Regulatory Commission are consistent with environmental standards for the uranium nuclear fuel cycle issued by the Environmental Protection Agency in reference 45. Table 8 presents the estimated total whole body radiation exposure to the total population within 50 miles from the assumed radioactivity releases compared with the radiation exposure received by the same population from natural background radioactivity, as reported in references 26, 32 and 46. As shown in Tables 7 and 8, conservative estimates of the exposures to members of the public from the Naval nuclear propulsion program are far less than either the Environmental Protection Agency standards, the guidelines of the Nuclear Regulatory Commission or the exposure from natural background radioactivity.



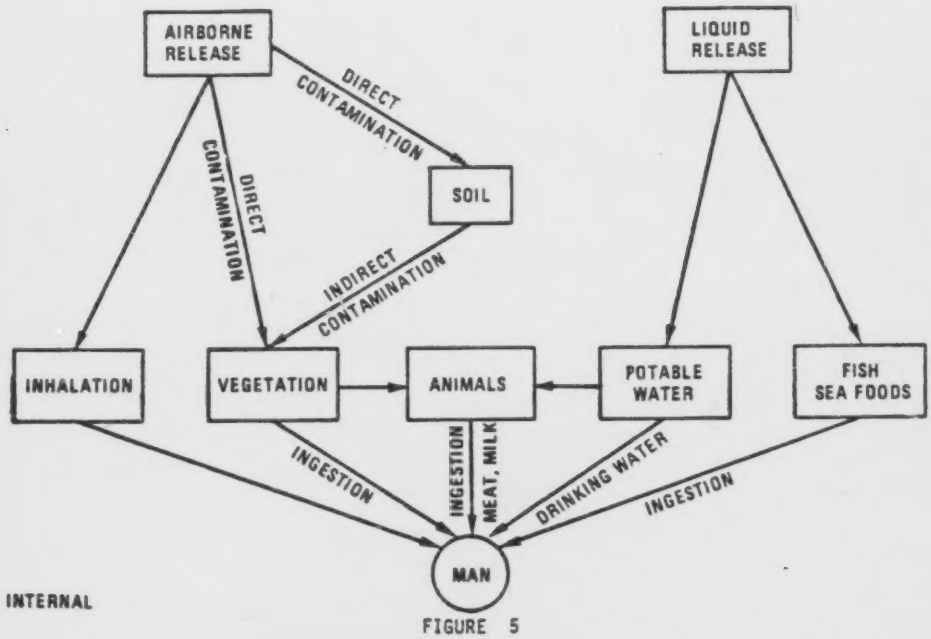


FIGURE 5

PATHWAYS FOR EXTERNAL AND INTERNAL EXPOSURE OF MAN FROM AIRBORNE AND LIQUID RELEASES OF RADIOACTIVE EFFLUENTS

TABLE 5 RADIONUCLIDE RELEASES ASSUMED FOR ENVIRONMENTAL PATHWAYS ANALYSIS

Radionuclide	Assumed Annual Release, Curie	
	Liquid Release	Airborne Release
Cobalt 60	0.001	0.001
Tritium	0.100	0.001
Carbon 14	*	0.100
Krypton 83m	*	0.020
Krypton 85m	*	0.024
Krypton 87	*	0.050
Krypton 88	*	0.020
Xenon 131m	*	0.005
Xenon 133m	*	0.010
Xenon 133	*	0.210
Xenon 135	*	0.250
Argon 41	*	0.410

*These gaseous radionuclides are released into the air, not into water.

TABLE 6 ENVIRONMENTAL EXPOSURE TIMES, CONSUMPTION AND CONCENTRATION PARAMETERS ASSUMED FOR ENVIRONMENTAL PATHWAYS ANALYSIS

Pathway Parameter*	Assumed Parameter Value For Highest Individual	For Average Individual
Fraction of Year Occupancy		
For Air Immersion	1	1
For Land Deposition	1	1
Along Shoreline	.05	.0005
Swimming	.01	.0001
Boating	.01	.0001
Food Consumption		
Leafy vegetables, Kg/year	72	18
Water, liters/year	730	180
Fish,** Kg/year	18	2.3
Mollusks,** Kg/year	9	.25
Crustacea,** Kg/year	9	.90
Sediment, Kg/year	1	.10

* Refer to Figure 5

** Cobalt 60 was assumed to concentrate from sea water to the edible flesh of fish, mollusks, and crustacea by factors as follows: fish, 650; mollusks, 170; crustacea, 1,700, based on reference 44.

TABLE 7 ESTIMATED MAXIMUM RADIATION EXPOSURE TO AN INDIVIDUAL FOR ASSUMED LIQUID AND AIRBORNE RADIOACTIVITY RELEASES FROM SHIPYARDS ENGAGED IN NAVAL NUCLEAR PROPULSION WORK

	Maximum Exposure To An Individual	
	NRC Guideline millirem/year	Estimated Value millirem/year
From Radionuclides In Liquid Releases	5 whole body, or any organ	less than 1
From Gaseous Radionuclides In Airborne Releases	5 whole body, or 15 skin	less than 1
From Other Radionuclides In Airborne Releases	15 any organ	less than 1

TABLE 8 ESTIMATED TOTAL WHOLE BODY RADIATION EXPOSURE TO GENERAL PUBLIC WITHIN 50 MILES FOR ASSUMED LIQUID AND AIRBORNE RADIOACTIVITY RELEASES FROM SHIPYARDS ENGAGED IN NAVAL NUCLEAR PROPULSION WORK

Exposure Due to Natural Background Radiation	Exposure Due to Assumed Radioactive Releases
Approximately 100,000 man rem per year	less than 1 man rem per year

AUDITS AND REVIEWS

The requirements and procedures for control of radioactive waste are important parts of the training programs for everyone involved with radioactivity in the Naval nuclear propulsion program. Such training is part of the initial qualification of shipyard workers and of Naval personnel assigned to ships and bases, and is required to be repeated regularly. Emphasis on this training is part of the concept that radiological control personnel alone cannot cause radiological work to be well performed; production and operations personnel and all levels of management are required to be involved in the control of radioactivity.

Checks and balances of several kinds are also set up to help ensure control of radioactivity. First, written procedures exist which require verbatim compliance. Radiological control personnel monitor various steps in radioactive waste processing. In each shipyard an independent organization, separate from the radiological control organization, audits all aspects of radioactive waste processing. Audits are performed by representatives from Naval Reactors headquarters who are assigned full time at each shipyard. Radiological control personnel from headquarters also conduct periodic inspections of each shipyard. In addition, shipyards have made detailed assessments of the environmental effects of shipyard operations and have published reports on the results of these assessments. Similarly, there are multiple levels of audits and inspections for the other Navy shore facilities, tenders, and nuclear-powered ships and for other radiologically controlled functions such as transportation. Even the smallest audit findings are followed up to ensure proper recovery and permanent corrective actions are taken and to help minimize the potential for future deficiencies.

The policy of the Navy is to provide for close cooperation and effective communication with state radiological officials involving occurrences that might cause concern because of radiological effects outside the ships or shore facilities. The Navy has reviewed radioactive waste disposal, radiological environmental monitoring, transportation and other radiological matters with state radiological officials in the states where Navy nuclear-powered ships are based or overhauled. Although there were no occurrences in 1984 which resulted in radiological effects to the public outside these facilities, states were notified when inquiries showed public interest in the possibility that such events had occurred. The Navy has encouraged states to conduct independent radio-

logical environmental monitoring in harbors where Naval nuclear-powered ships are based or overhauled; the results of monitoring by states have been consistent with Navy results.

The U. S. Environmental Protection Agency (EPA) has conducted detailed reviews of the Navy's procedures for controlling radioactive waste and for radiological environmental monitoring. An Environmental Protection Agency laboratory has conducted detailed environmental surveys of celected U. S. harbors (references 38, 40, 47, 48, 49, 50, 51). This laboratory has performed these surveys in the harbors at Pascagoula, Mississippi; Charleston, South Carolina; Pearl Harbor, Hawaii; San Diego, California; Vallejo, California; New London, Connecticut; Newport News, Virginia; Norfolk, Virginia; Bremerton, Washington; and Kittery, Maine-Portsmouth, New Hampsnire. Environmental Protection Agency results have been consistent with Navy results. In the latest such Environmental Protection Agency survey of an operating shipyard conducted in 1977 at the Portsmouth Naval Shipyard, the Environmental Protection Agency analyzed harbor water, sediment, marine life and air for radioactivity. No radioactivity from shipyard operations was detected.

CONCLUSIONS

1. The total gamma radioactivity in liquids released into all ports and harbors from the U. S. Naval nuclear propulsion program was less than 0.002 curie in 1984.

2. No increase of radioactivity above normal background levels has been detected in harbor water where U. S. Naval nuclear-powered ships are based, overhauled, or constructed.

3. Liquid waste from U. S. Naval nuclear-powered ships and their support facilities have not caused a measurable increase in the general background radioactivity of the environment.

4. Low-level cobalt 60 radioactivity in harbor bottom sediment is detectable around a few operating base and snipyard piers from low level liquid releases in the 1960's. Cobalt 60 is not detectable above background levels in general harbor bottom areas away from these piers. Maximum total radioactivity observed in a U. S. harbor of less than 0.01 curie of cobalt 60 is small compared to the naturally occurring radioactivity. Comparison to previous environmental data summarized in references 1 through 19 shows that these environmental cobalt 60 levels are continuing to decrease.

5. Conservative estimates of radiation exposures to members of the public from the Naval nuclear propulsion program are far less than either the Environmental Protection Agency environmental standards, the guidelines of the Nuclear Regulatory Commission or the exposure from natural background radioactivity.

6. Procedures used by the Navy to control discharges of radioactivity from U. S. Naval nuclear-powered ships and their support facilities have been effective in protecting the environment and the health and safety of the general public. Independent radiological environmental monitoring performed by the U. S. Environmental Protection Agency and states have confirmed the adequacy of these procedures.

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APPENDIX
ENVIRONMENTAL MONITORING SURVEY CHARTS

Environmental monitoring survey charts for harbors monitored for radioactivity associated with U. S. Naval nuclear-powered ships in the U. S. and possessions during 1984 are listed below and included in this appendix. The sampling locations for harbor water and harbor sediment are shown. In addition, shoreline survey areas and the locations of posted dosimetry devices are shown on the figures.

Figure No.	Location
	California
1	U. S. Naval Air Station, Alameda
2	Hunters Point Shipyard, San Francisco
3	Mare Island Naval Shipyard, Vallejo
4	San Diego Harbor
5	San Diego Harbor, Ballast Point Area
	Connecticut
6	Electric Boat Division, Groton
7	U. S. Naval Submarine Support Facility, New London Harbor
8	State Pier Area, New London
	Florida
9	Port Canaveral
	Georgia
10	U. S. Naval Submarine Support Facility, Kings Bay, St. Marys
	Guam
11	Apra Harbor
	Hawaii
12	Pearl Harbor Area
13	Pearl Harbor Naval Shipyard
14	U. S. Naval Submarine Base, Pearl Harbor
	New Hampshire/Maine
15	Portsmouth Naval Shipyard
	South Carolina
16	U. S. Naval Station and Naval Shipyard, Charleston
17	U. S. Naval Weapons Station, Charleston

Virginia

18 Newport News Shipbuilding and Dry Dock Co., Newport News

19 Norfolk Naval Shipyard, Portsmouth

20 U. S. Naval Station Norfolk, Destroyer and Submarine Piers

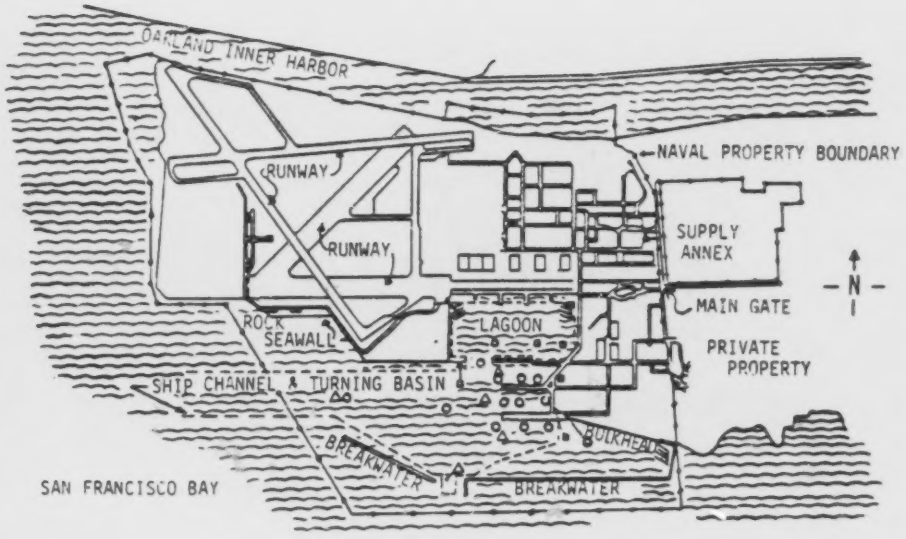
21 Norfolk—Portsmouth Virginia Area

Washington

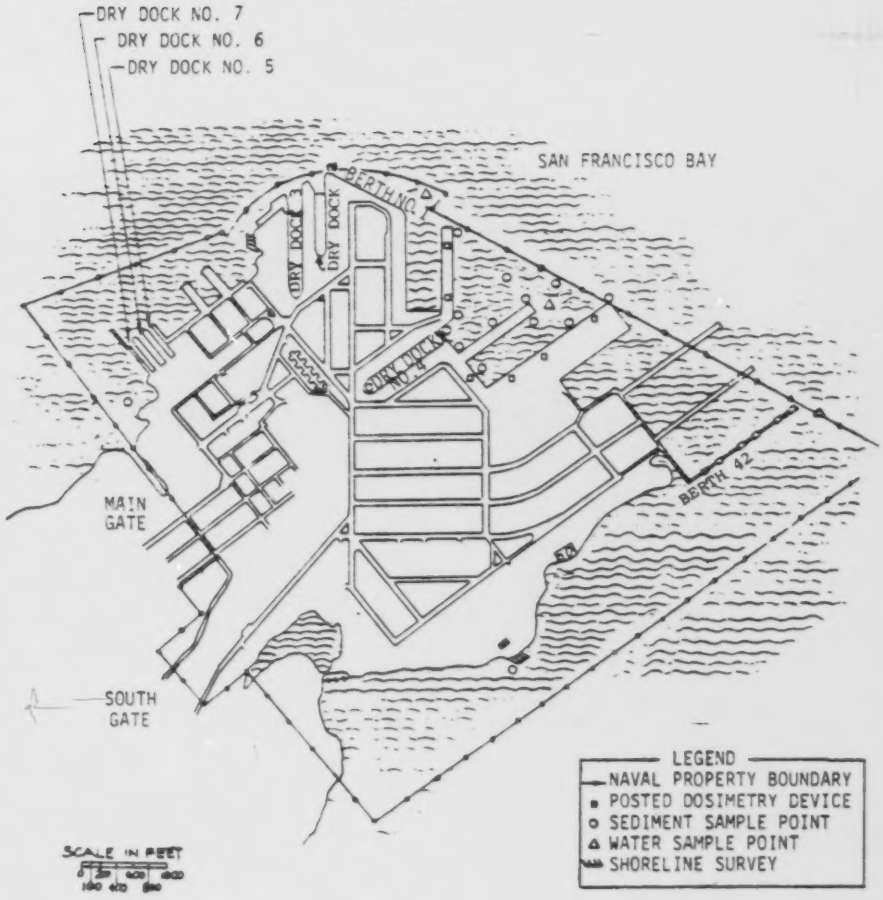
22 Puget Sound Naval Shipyard

23 Bangor/Hood Canal

FIGURE 1
ENVIRONMENTAL MONITORING LOCATIONS
AT THE U. S. NAVAL AIR STATION
ALAMEDA, CALIFORNIA

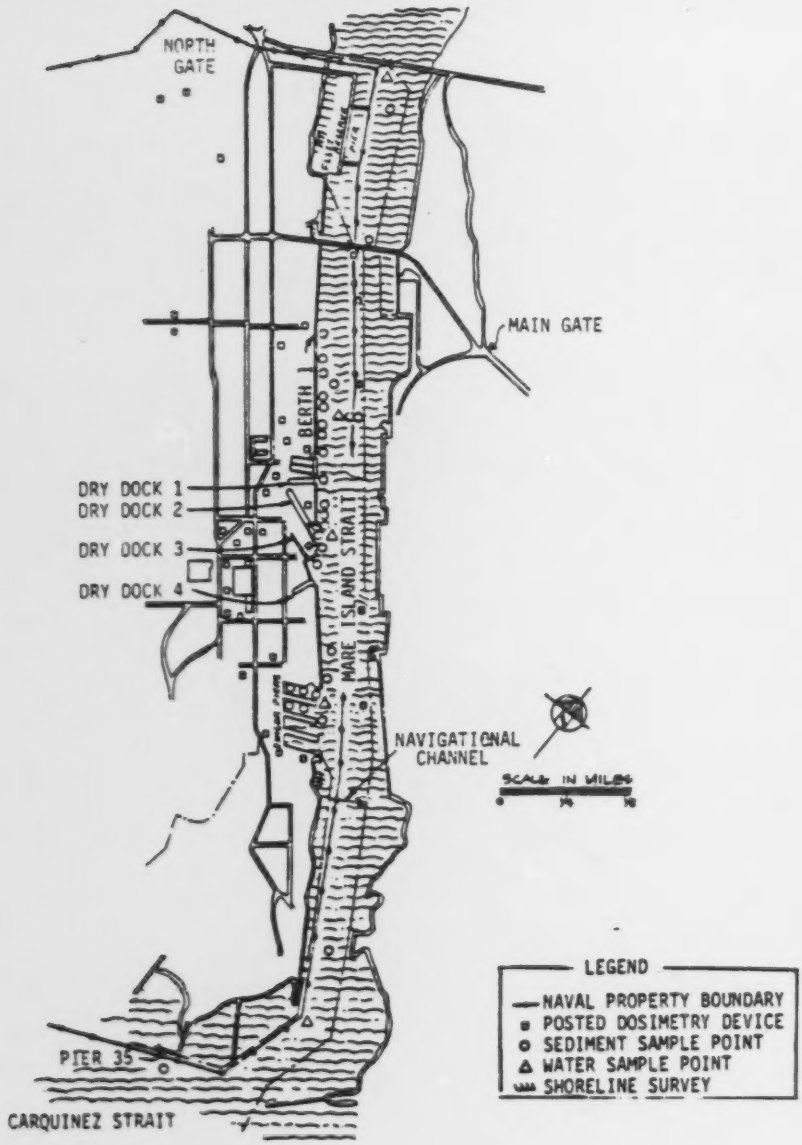


ENVIRONMENTAL MONITORING LOCATIONS AT THE
HUNTERS POINT SHIPYARD
SAN FRANCISCO, CALIFORNIA
FIGURE 2



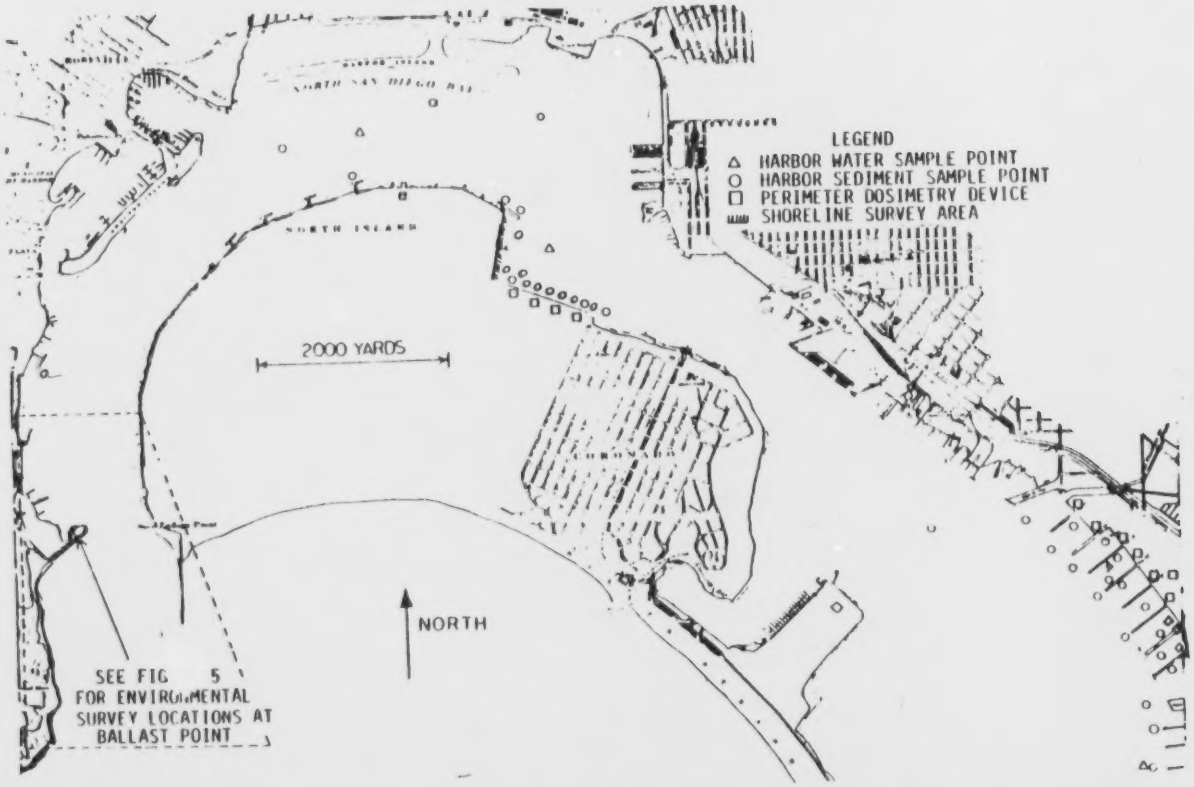
ENVIRONMENTAL MONITORING LOCATIONS AT THE
MARE ISLAND NAVAL SHIPYARD
VALLEJO, CALIFORNIA

FIGURE 3



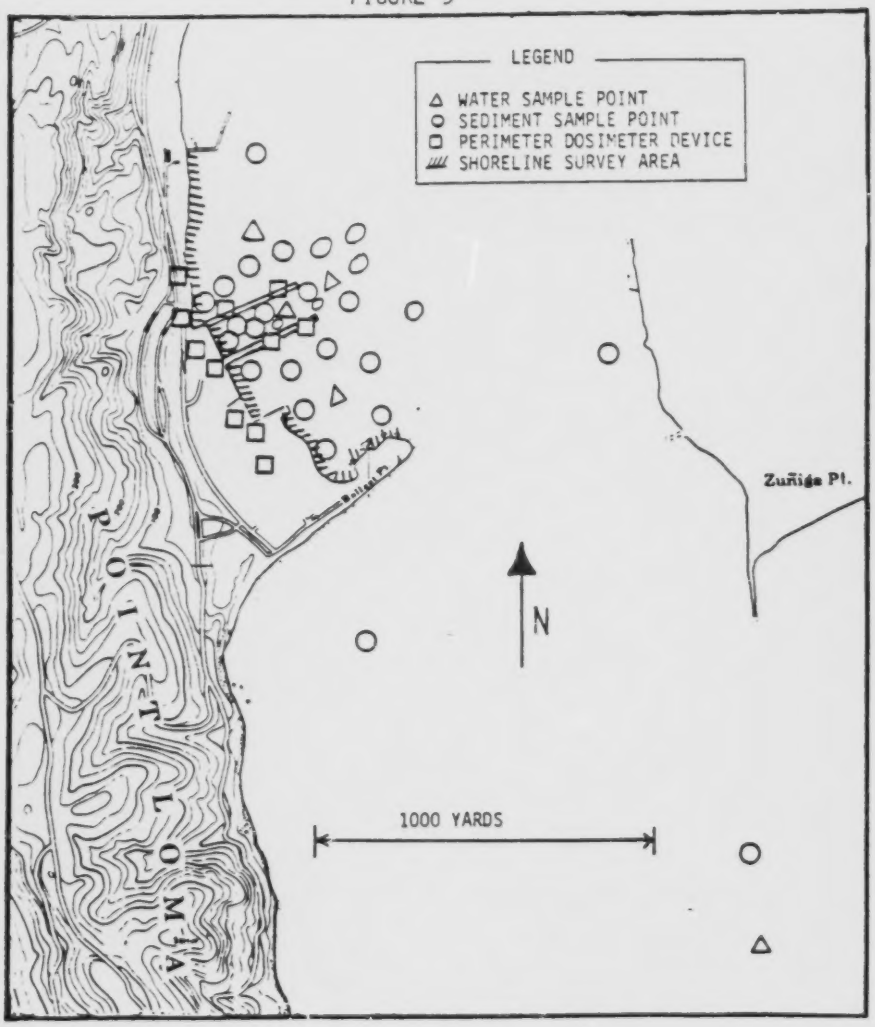
ENVIRONMENTAL MONITORING LOCATIONS AT SAN DIEGO BAY, CALIFORNIA

FIGURE 4



ENVIRONMENTAL MONITORING LOCATIONS AT
BALLAST POINT, SAN DIEGO HARBOR

FIGURE 5



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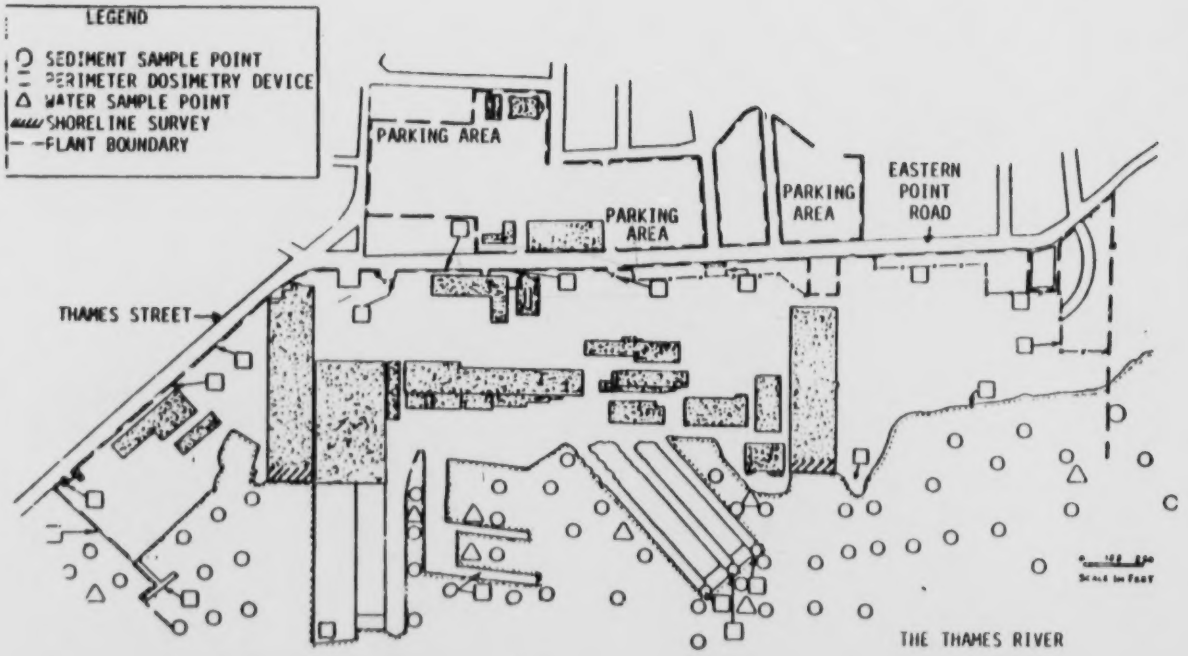
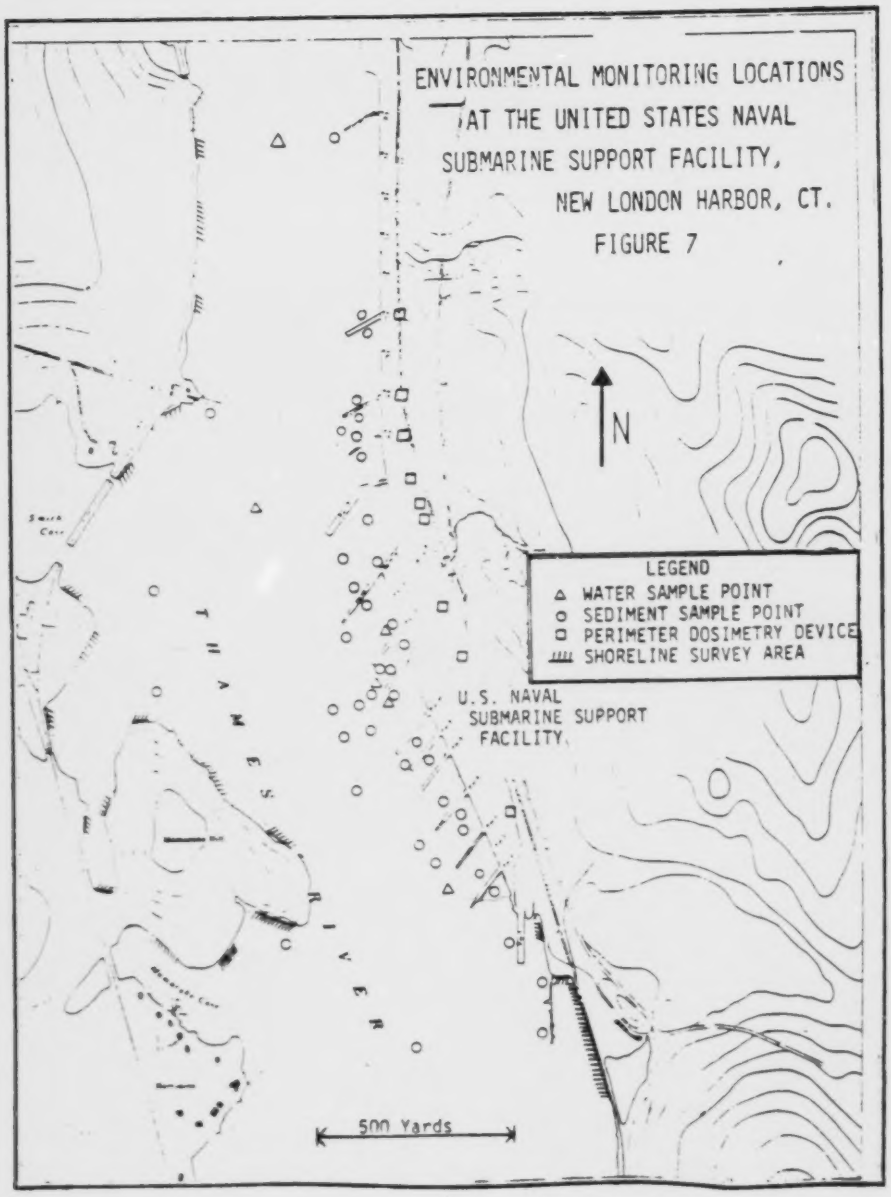
ENVIRONMENTAL MONITORING LOCATIONS
AT GENERAL DYNAMICS/ELECTRIC BOAT
GROTON, CT.
FIGURE 6




ENVIRONMENTAL MONITORING LOCATIONS
AT THE UNITED STATES NAVAL
SUBMARINE SUPPORT FACILITY,
NEW LONDON HARBOR, CT.
FIGURE 7
N
LEGEND
WATER SAMPLE POINT
SEDIMENT SAMPLE POINT
PERIMETER DOSIMETRY DEVICE
SHORELINE SURVEY AREA
U.S. NAVAL
SUBMARINE SUPPORT
FACILITY
THAMES RIVER
500 Yards

ENVIRONMENTAL MONITORING LOCATIONS
AT STATE PIER AREA, NEW LONDON, CT
FIGURE 8

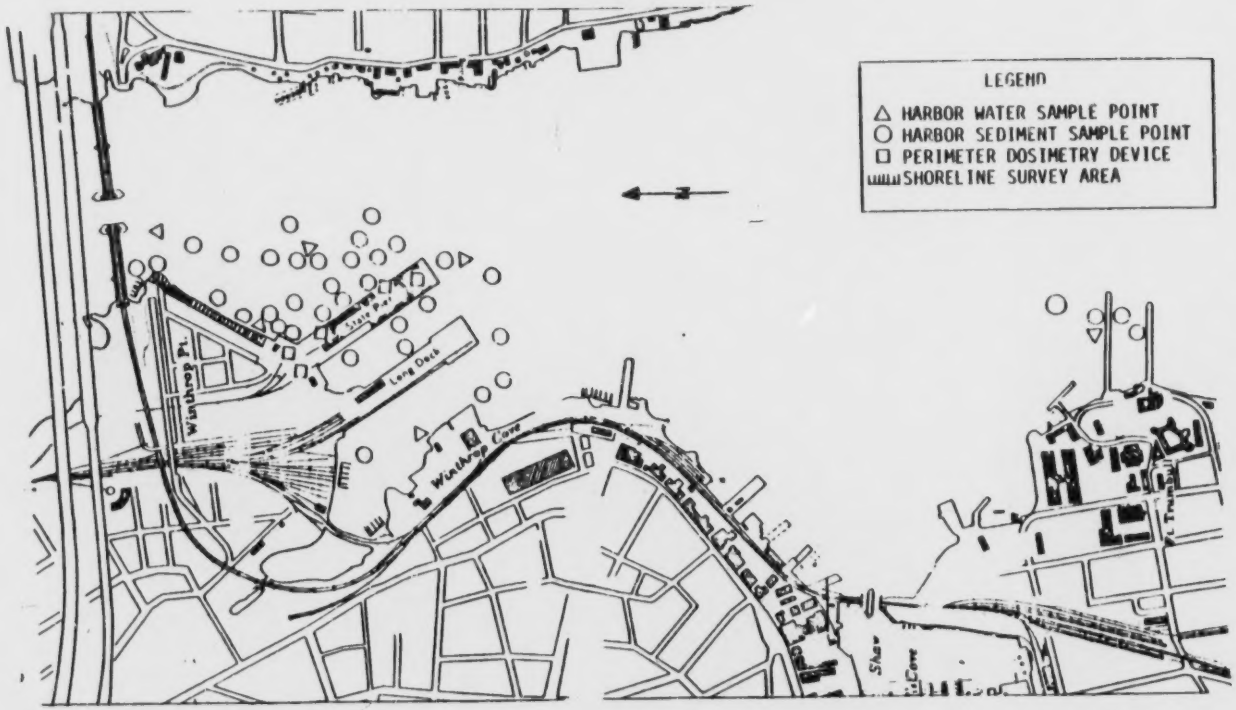
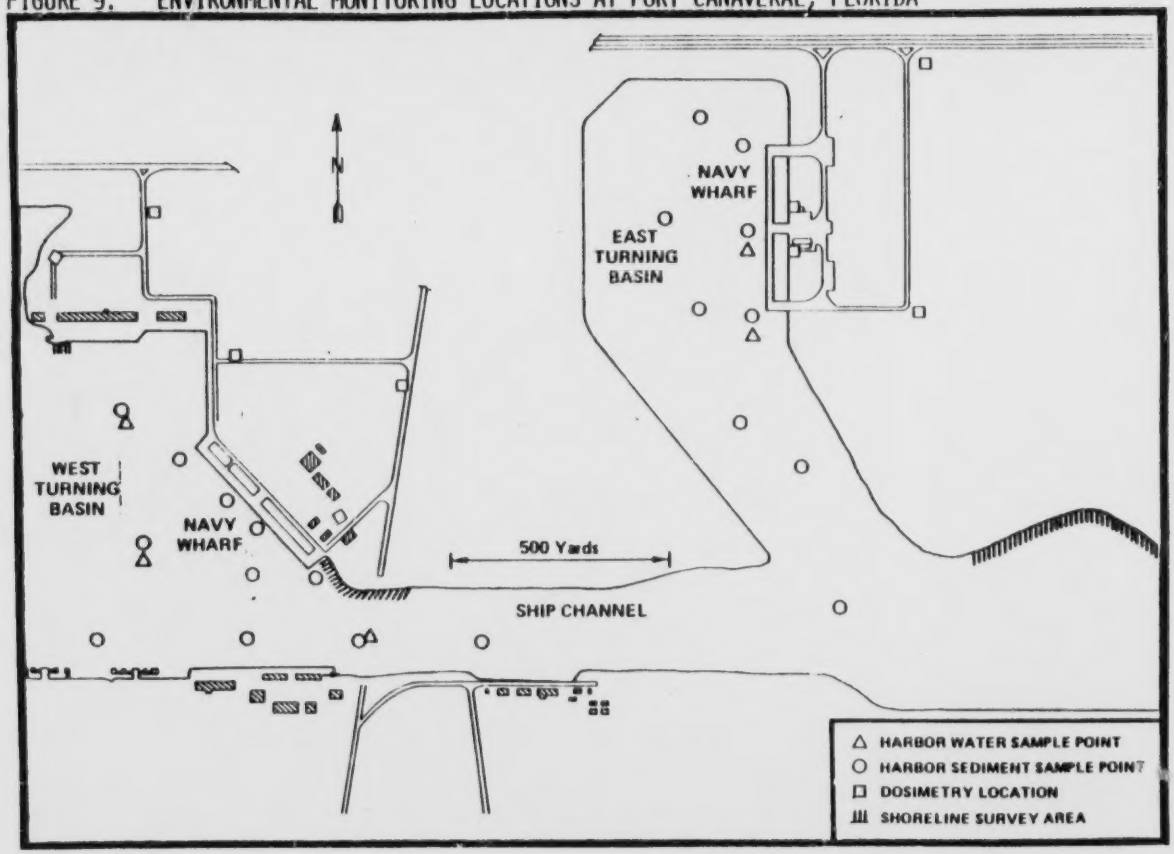
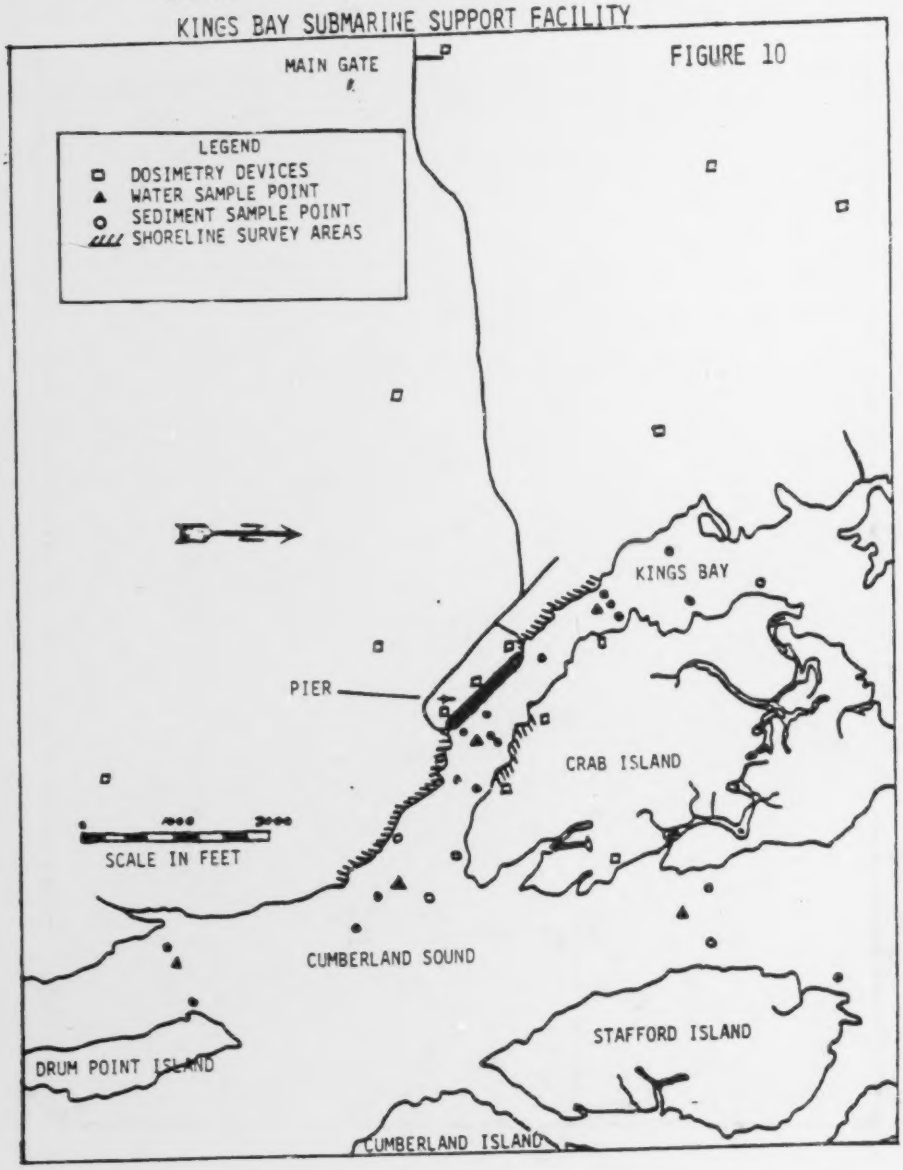


FIGURE 9. ENVIRONMENTAL MONITORING LOCATIONS AT PORT CANAVERAL, FLORIDA



ENVIRONMENTAL MONITORING LOCATIONS AT
KINGS BAY SUBMARINE SUPPORT FACILITY



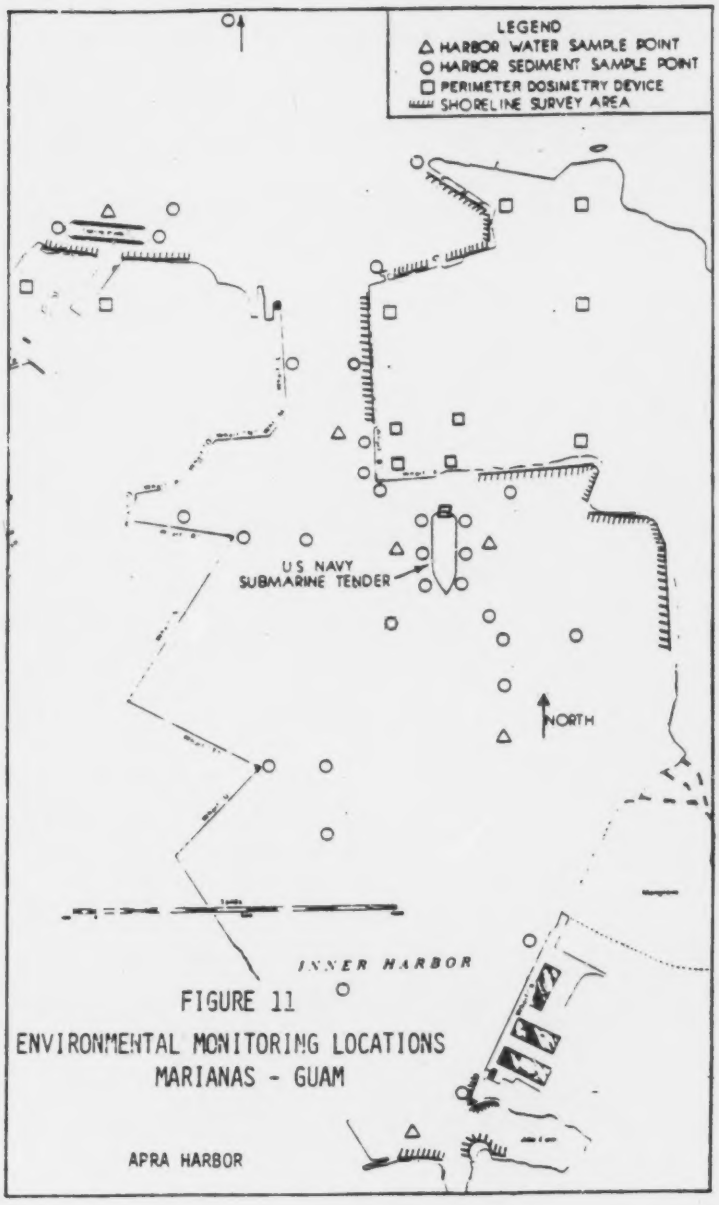
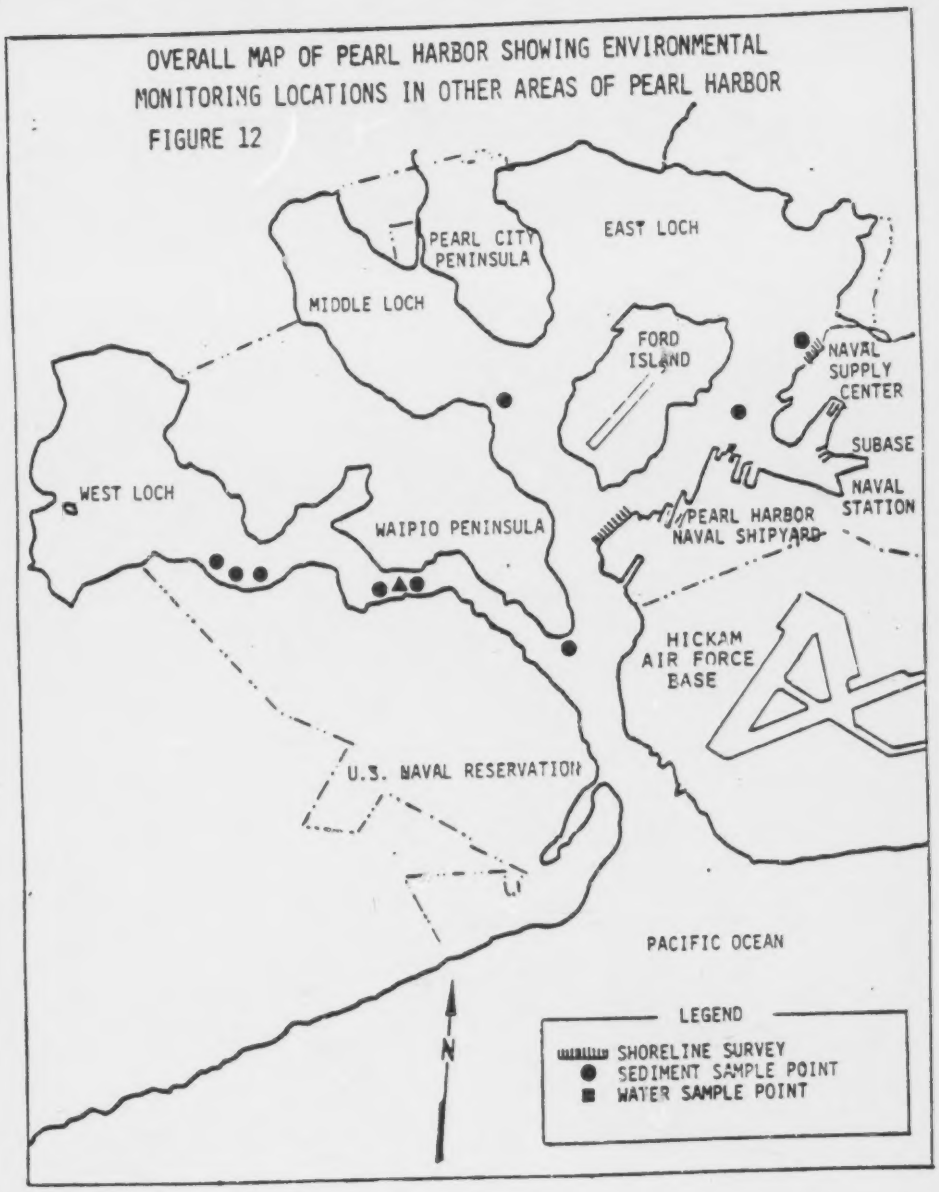


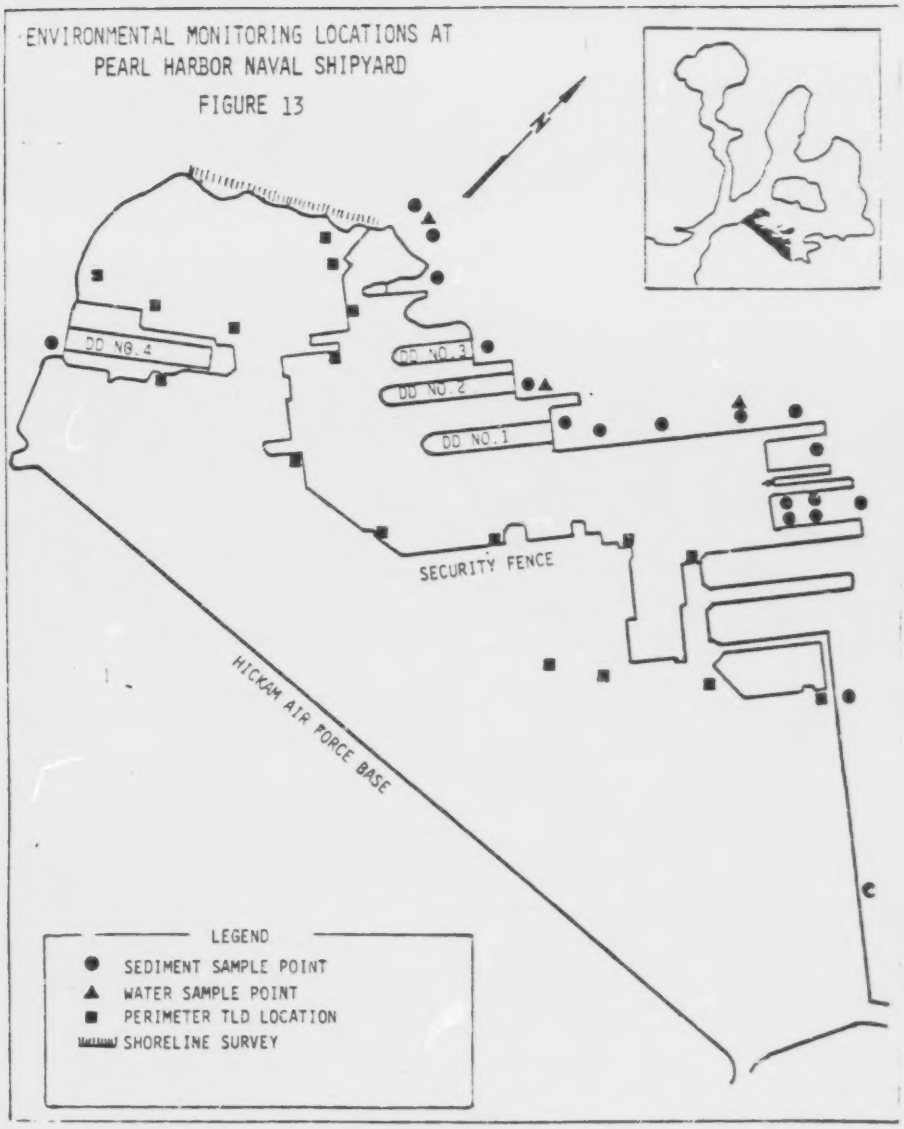
FIGURE 11

ENVIRONMENTAL MONITORING LOCATIONS
MARIANAS - GUAM

OVERALL MAP OF PEARL HARBOR SHOWING ENVIRONMENTAL MONITORING LOCATIONS IN OTHER AREAS OF PEARL HARBOR

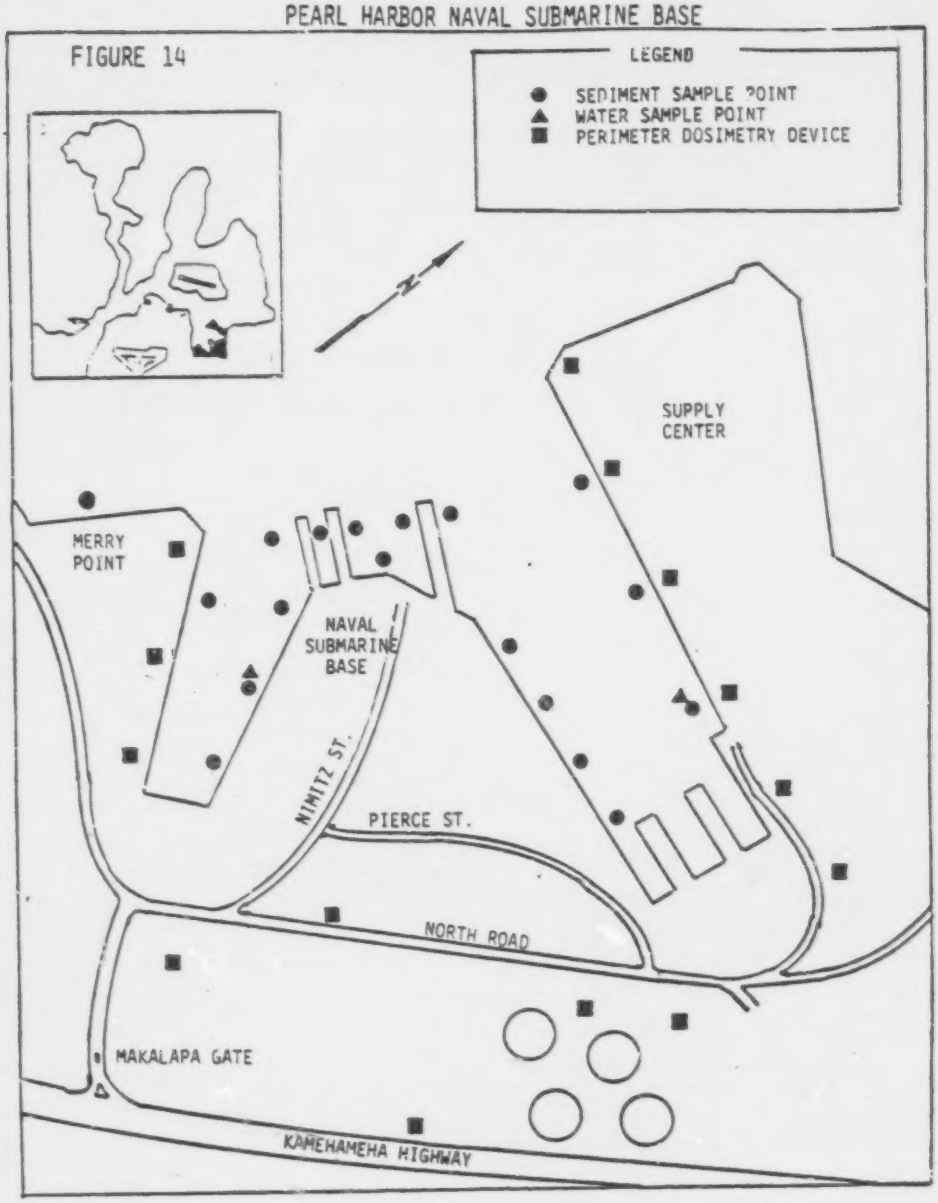
FIGURE 12




ENVIRONMENTAL MONITORING LOCATIONS AT
PEARL HARBOR NAVAL SHIPYARD
FIGURE 13
DD NO. 4
DD NO. 3
DD NO. 2
DD NO. 1
SECURITY FENCE
HICKAM AIR FORCE BASE
LEGEND
SEDIMENT SAMPLE POINT
WATER SAMPLE POINT
PERIMETER TLD LOCATION
SHORELINE SURVEY

ENVIRONMENTAL MONITORING LOCATIONS AT
PEARL HARBOR NAVAL SUBMARINE BASE

FIGURE 14



ENVIRONMENTAL MONITORING LOCATIONS
AT PORTSMOUTH NAVAL SHIPYARD
PORTSMOUTH-KITTERY HARBOR
FIGURE 15

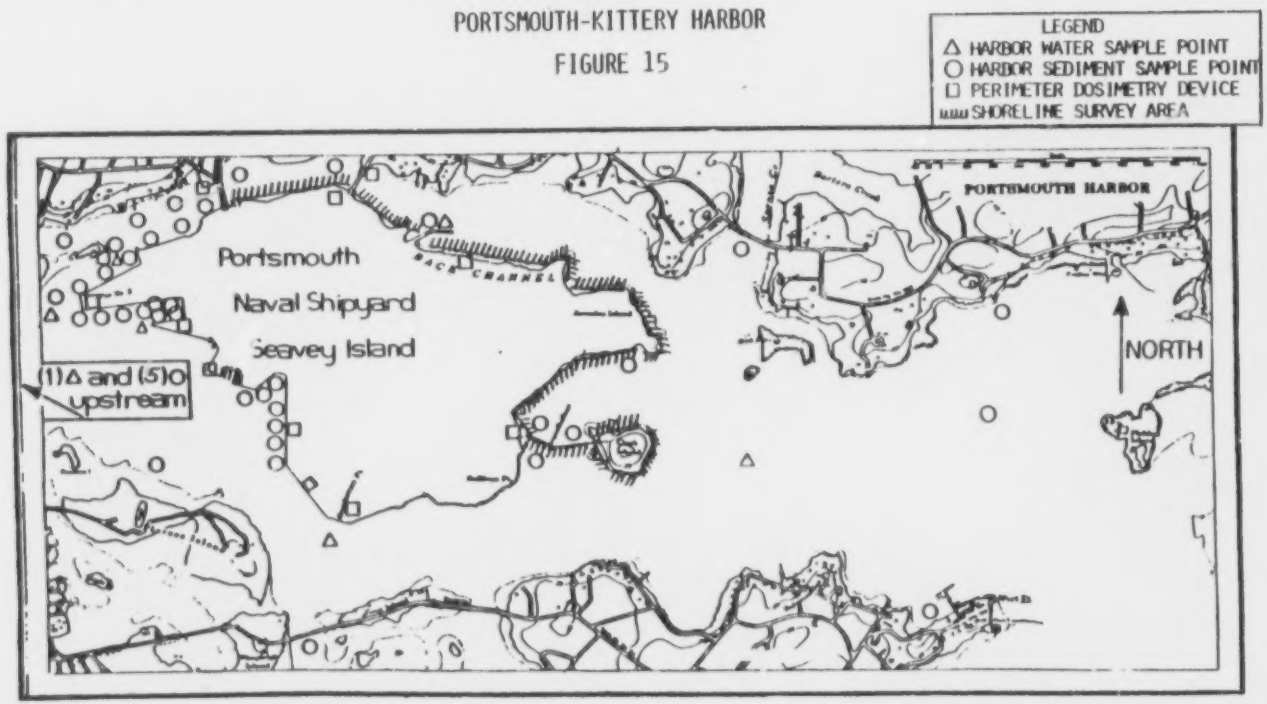


FIGURE 16. U.S. NAVAL STATION & NAVAL SHIPYARD, CHARLESTON, SC.

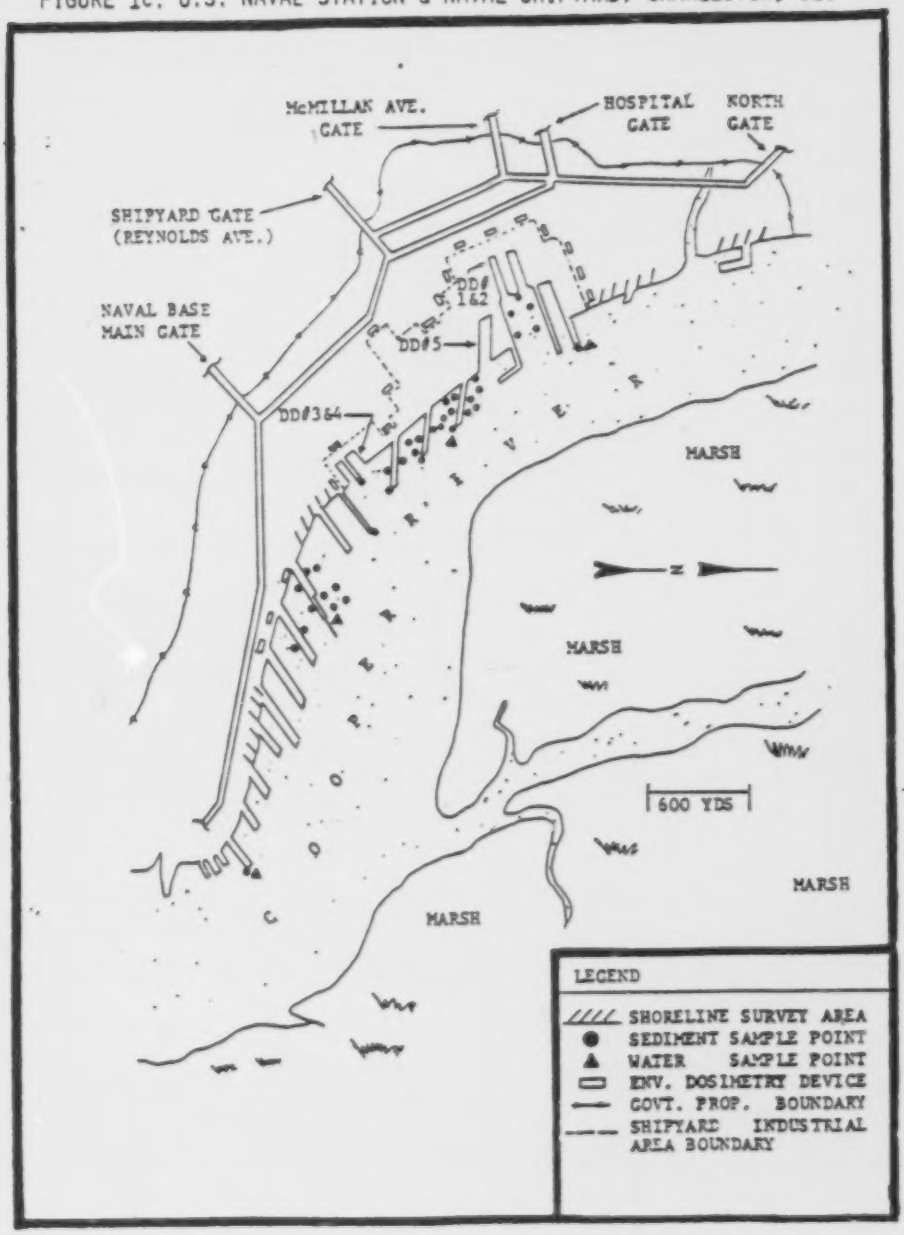
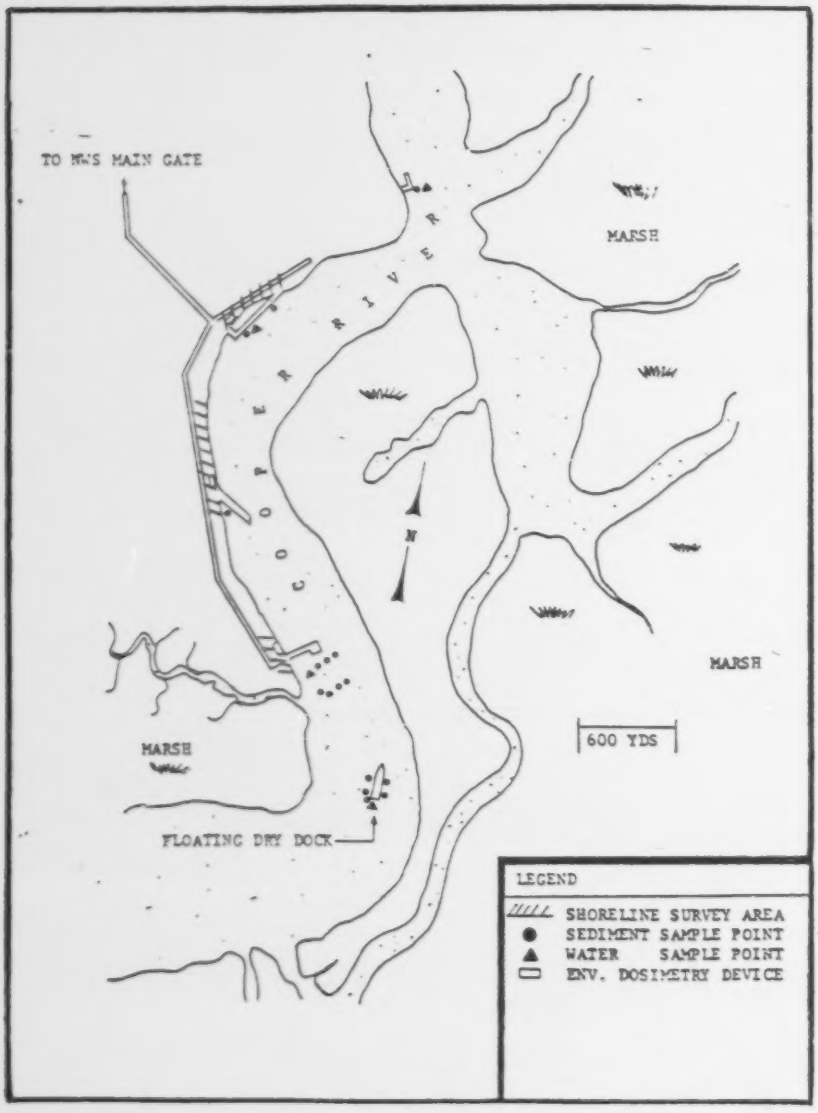


FIGURE 17. ENVIRONMENTAL MONITORING, U.S. NAVAL WEAPONS STATION, CHARLESTON



ENVIRONMENTAL MONITORING LOCATIONS
AT NEWPORT NEWS SHIPBUILDING AND DRY DOCK COMPANY
FIGURE 18

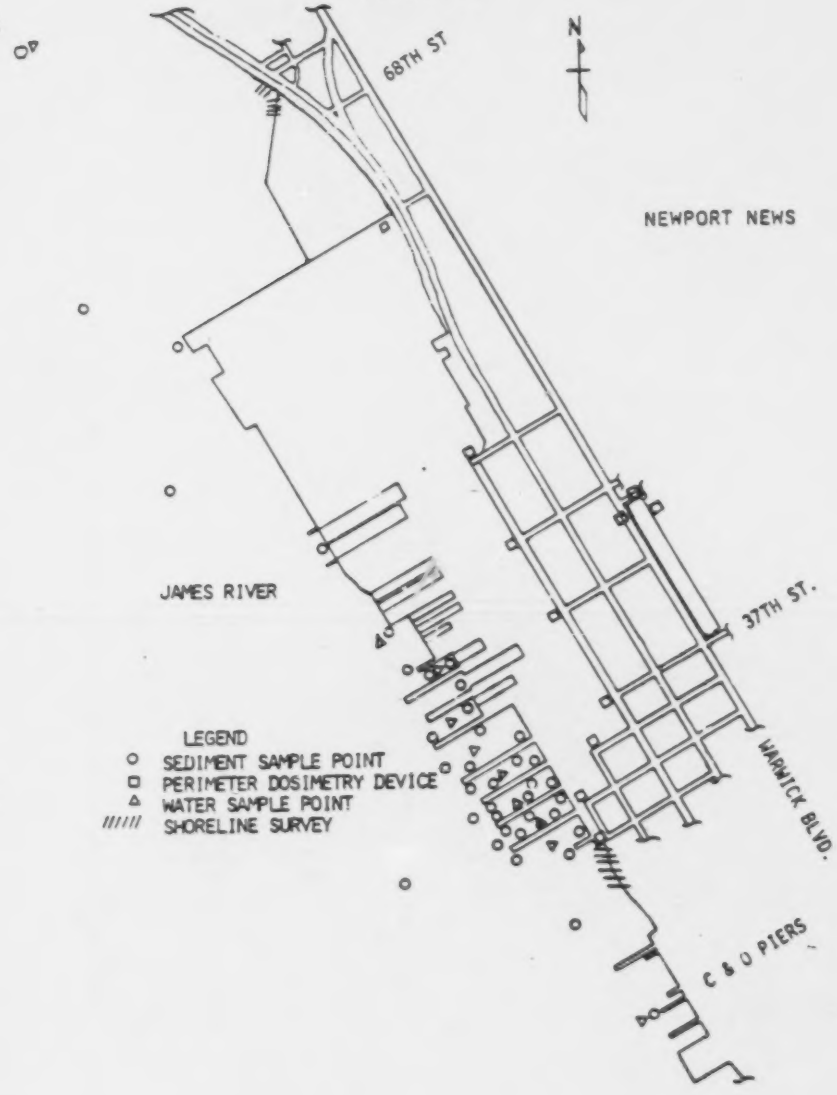
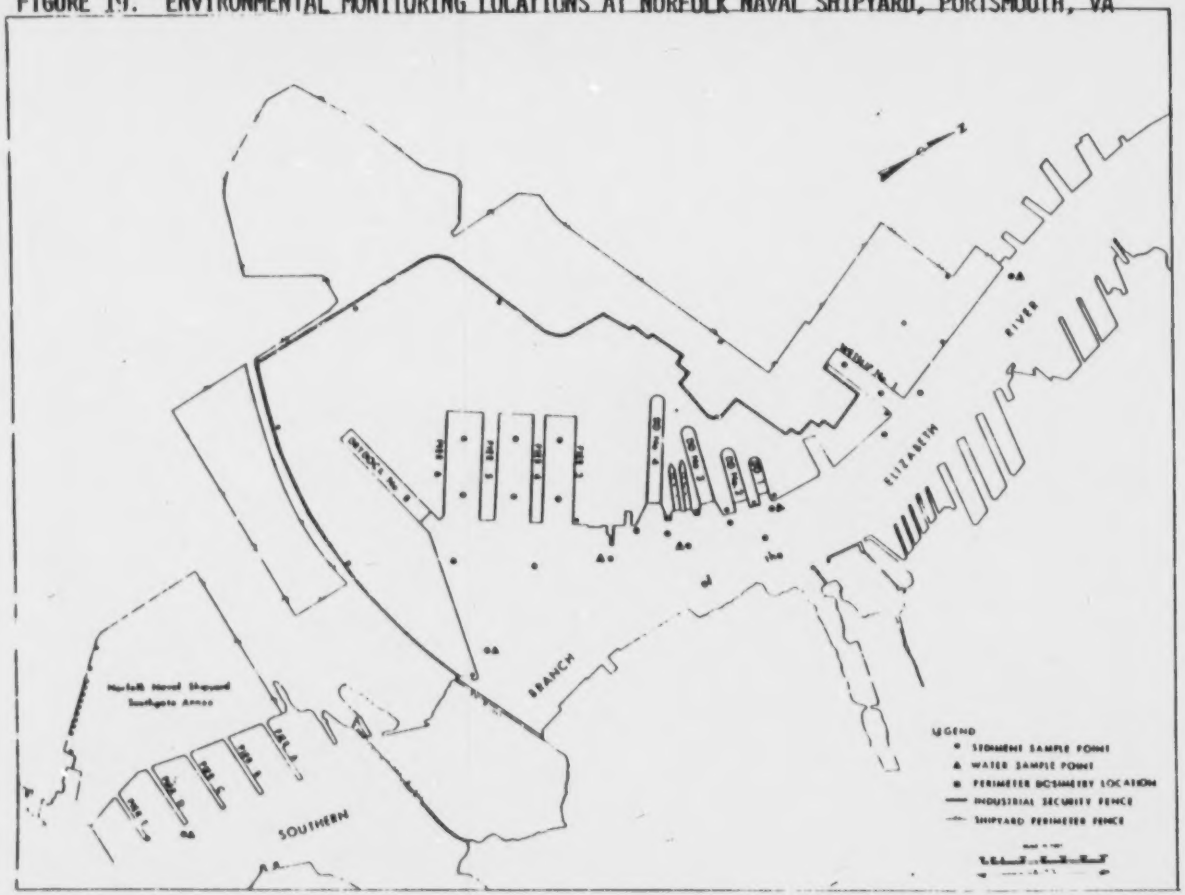


FIGURE 19. ENVIRONMENTAL MONITORING LOCATIONS AT NORFOLK NAVAL SHIPYARD, PORTSMOUTH, VA



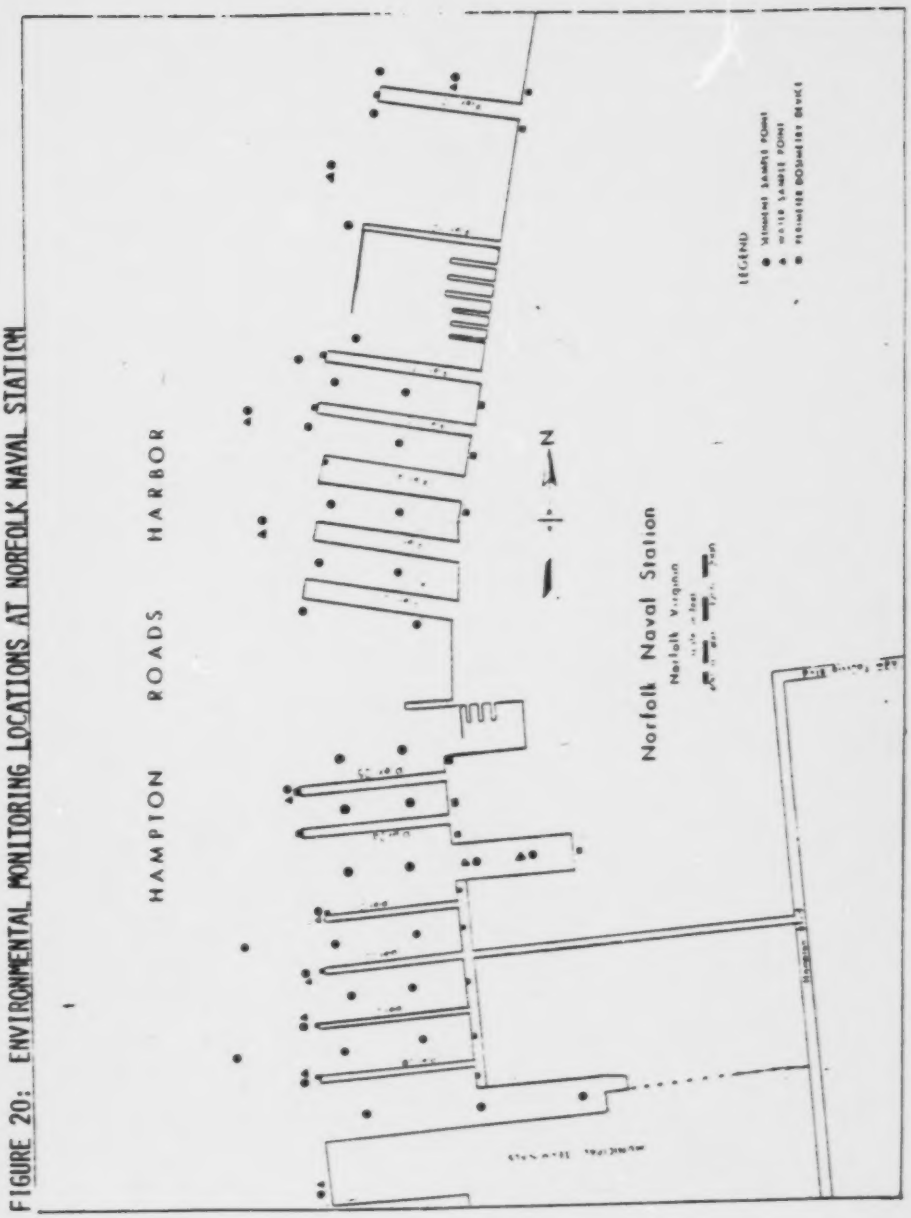
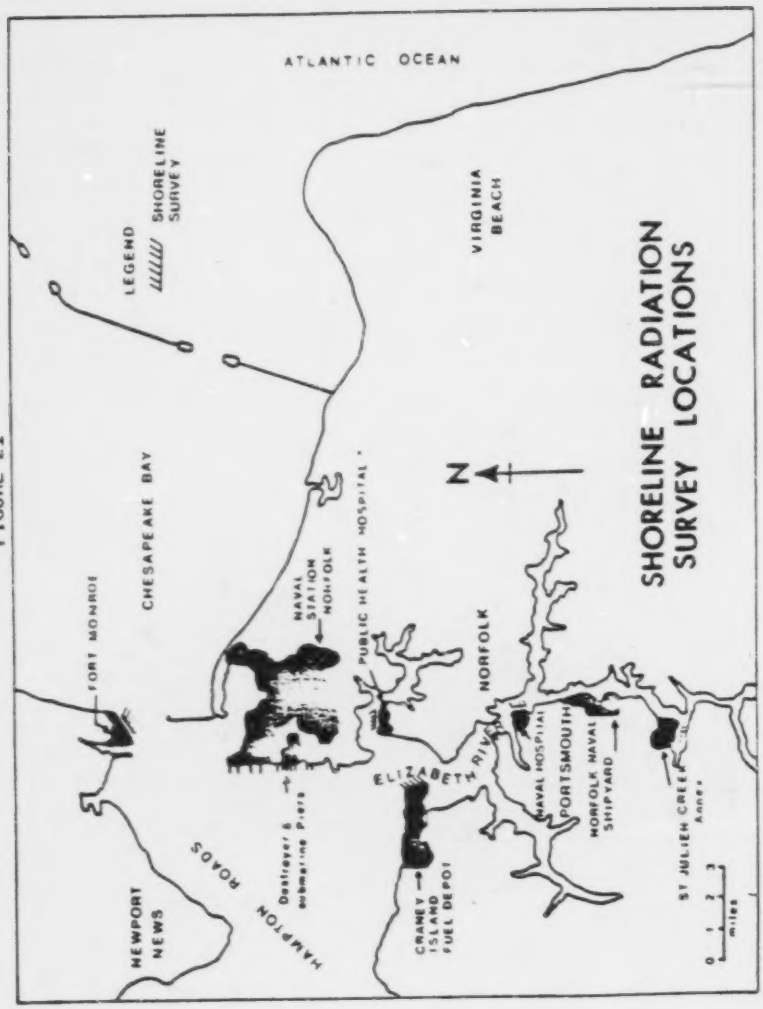


FIGURE 20: ENVIRONMENTAL MONITORING LOCATIONS AT NORFOLK NAVAL STATION

FIGURE 21


ATLANTIC OCEAN
LEGEND
SHORELINE SURVEY
VIRGINIA BEACH
CHESAPEAKE BAY
FORT MONROE
NAVAL STATION NORFOLK
PUBLIC HEALTH HOSPITAL
N
NORFOLK
NEWPORT NEWS
HAMPTON ROADS
Destroyer & submarine piers
ELIZABETH RIVER
CRANEY ISLAND FUEL DEPOT
NAVAL HOSPITAL
PORTSMOUTH
NORFOLK NAVAL SHIPYARD
ST JULIEN CREEK Annex
0 1 2 3 miles
SHORELINE RADIATION SURVEY LOCATIONS

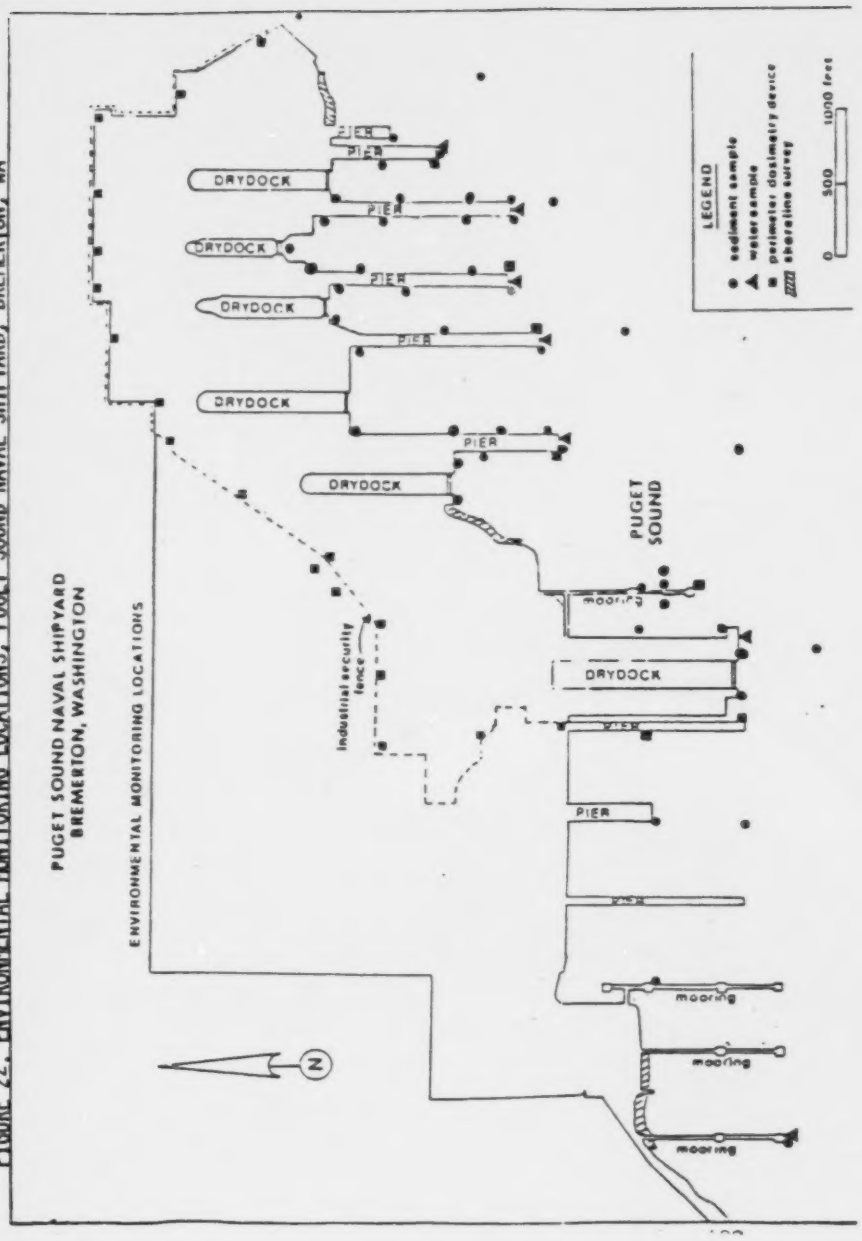
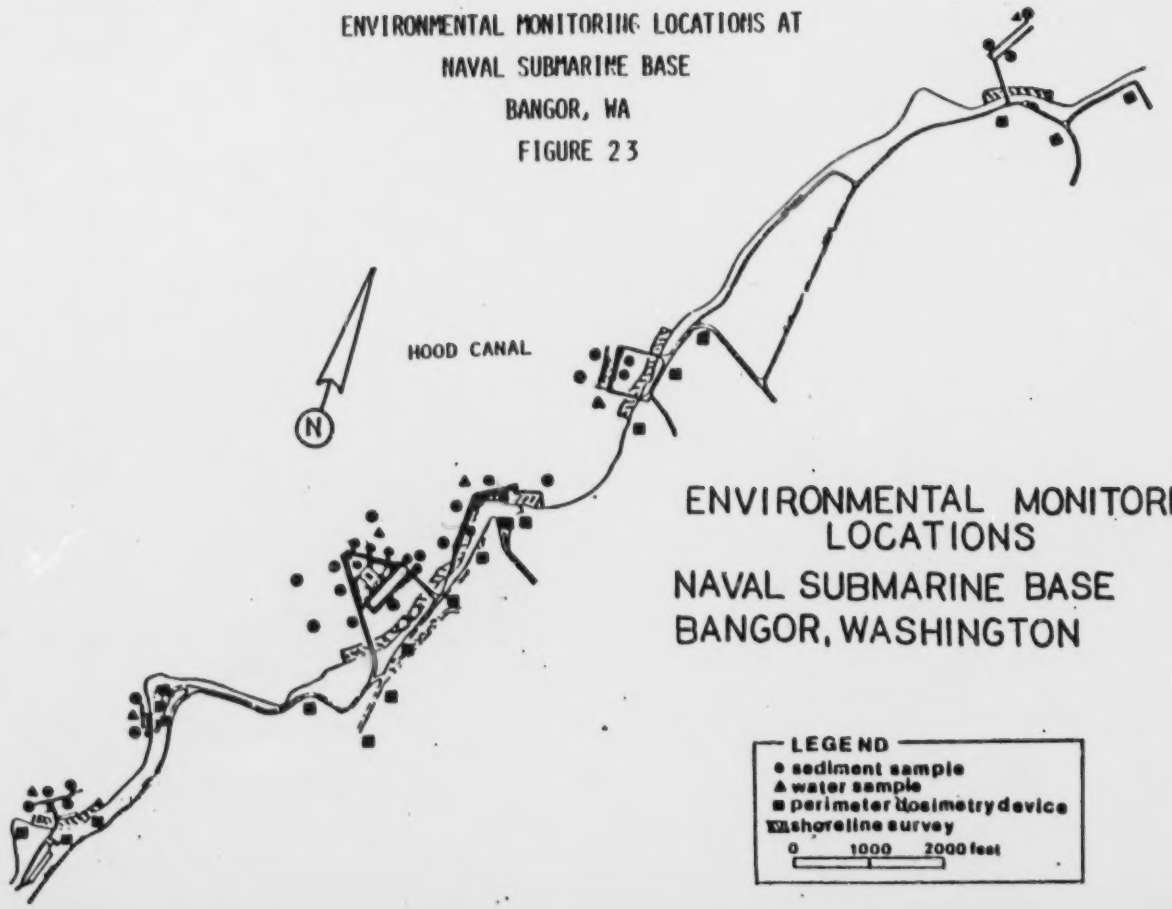


FIGURE 22. ENVIRONMENTAL MONITORING LOCATIONS, PUGET SOUND NAVAL SHIPYARD, BREMERTON, WA

ENVIRONMENTAL MONITORING LOCATIONS AT
NAVAL SUBMARINE BASE
BANGOR, WA
FIGURE 23



APPENDIX D

Report NT-85-2
February 1985

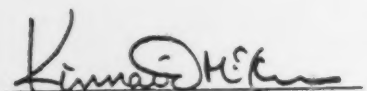
OCCUPATIONAL RADIATION EXPOSURE FROM U. S. NAVAL NUCLEAR PROPULSION PLANTS AND THEIR SUPPORT FACILITIES

1984

Prepared by

J. J. Mangeno and A. E. Tryon
Naval Nuclear Propulsion Program
Department of the Navy

Approved by



KINNAIRD R. McKEE
Admiral, U. S. Navy
Director, Naval Nuclear
Propulsion Program

TABLE OF CONTENTS

SUMMARY 1

EXTERNAL RADIATION EXPOSURE 3

Policy and Limits 3
Source of Radiation 4
Control of Radiation During Reactor Plant Operation 5
Control of Radiation in Support Facilities 5
Dosimetry 6
Physical Examinations 9
Shipyard, Tender, and Submarine Base Training 10
Nuclear Power Training 14
Radiation Exposure Reduction 14
Radiation Exposure Data 17

INTERNAL RADIOACTIVITY 27

Policy and Limits 27
Source of Radioactivity 27
Control of Airborne Radioactivity 28
Control of Radioactive Surface Contamination 29
Control of Food and Water 30
Wounds 30
Monitoring for Internal Radioactivity 31
Results of Internal Monitoring in 1983 32

EFFECTS OF RADIATION ON PERSONNEL 33

Exposure to Radiation Involves Some Risk 33
Studies of the Effects of Radiation on Humans 34
Numerical Estimates of Risk from Radiation 36
Radiation Exposure Comparisons 38
Extrapolations 40
Conclusions on the Effects of Radiation on Personnel 41

CLAIMS FOR RADIATION INJURY TO PERSONNEL 42

AUDITS AND REVIEWS 44

ABNORMAL OCCURRENCES 46

REFERENCES 48

LIST OF FIGURES

FIGURE 1 TOTAL RADIATION EXPOSURE RECEIVED BY MILITARY AND CIVILIAN PERSONNEL IN THE NAVAL NUCLEAR PROPULSION PROGRAM 1960-1984.....2

FIGURE 2 TOTAL RADIATION EXPOSURE RECEIVED BY SHIPYARD PERSONNEL FROM WORK ASSOCIATED WITH NAVAL NUCLEAR PROPULSION PLANTS 1958-1984.....23

LIST OF TABLES

TABLE 1 SHIPYARD FIRST REACTOR PLANT OPERATION AND FIRST RADIOACTIVE OVERHAUL WORK.....20

TABLE 2 OCCUPATIONAL RADIATION EXPOSURE RECEIVED BY PERSONNEL ASSIGNED TO TENDERS, BASES, AND NUCLEAR-POWERED SHIPS FROM OPERATION AND MAINTENANCE OF NAVAL NUCLEAR PROPULSION PLANTS.....21

TABLE 3 OCCUPATIONAL RADIATION EXPOSURE RECEIVED BY SHIPYARD PERSONNEL FROM WORK ASSOCIATED WITH NAVAL NUCLEAR PROPULSION PLANTS.....22

TABLE 4 SHIPYARD AND FLEET DISTRIBUTION OF PERSONNEL RADIATION EXPOSURE.....24

TABLE 5 DISTRIBUTION OF TOTAL LIFETIME RADIATION EXPOSURE ASSOCIATED WITH NAVAL NUCLEAR PROPULSION PLANTS.....25

TABLE 6 PERSONNEL RADIATION EXPOSURE FOR COMMERCIAL NUCLEAR POWER REACTORS LICENSED BY U.S. NUCLEAR REGULATORY COMMISSION.....26

TABLE 7 CLAIMS FOR RADIATION INJURY TO PERSONNEL.....43

TABLE 8 ABNORMAL OCCURRENCES IN THE NAVAL NUCLEAR PROPULSION PROGRAM.....47

SUMMARY

Radiation exposures to Navy and civilian personnel monitored for radiation associated with U.S. Naval nuclear propulsion plants are summarized in this report. Navy personnel manned seventeen tenders, three submarine bases, 131 nuclear-powered submarines and thirteen nuclear-powered surface ships which were in operation at the end of 1984. Eight shipyards were engaged in construction, overhaul and refueling of these ships. The benefits of nuclear propulsion in our most capable combatant ships have long been recognized, and our nuclear-powered ballistic missile submarines form the most invulnerable element of the United States strategic deterrent.

Figure 1 shows that the total radiation exposure in 1984 is less than one-fourth of the amount in the peak year of 1966, even though the number of nuclear-powered ships has more than doubled and the number of ships in overhaul has tripled since then. Total man-rem in this figure is the sum of the annual exposures of each person monitored for radiation.

No civilian or military personnel in the Naval Nuclear Propulsion Program have ever exceeded the Federal limit which allows five rem exposure for each year of age beyond age eighteen. Since 1967 no person has exceeded the Federal limit which allows up to three rem per quarter year, nor in this period has anyone exceeded the Navy's self-imposed limit of 5 rem per year for radiation associated with Naval nuclear propulsion plants.

No civilian or military personnel in the Naval Nuclear Propulsion Program have ever received more than one tenth the Federal annual occupational exposure limit from internal radiation exposure caused by radioactivity associated with Naval nuclear propulsion plants.

The average occupational exposure of each person monitored has been about one quarter rem per year. The total lifetime exposure from radiation associated with Naval nuclear propulsion plants to date for all personnel monitored since 1954 has averaged about one rem per person.

According to the standard methods for estimating risk, the risk to the group of personnel occupationally exposed to radiation associated with Naval nuclear propulsion plants is less than the risk these same personnel have from exposure to natural background radiation or to medical radiation. This risk is small compared to the risks accepted in normal industrial activities, and it is small compared to the risks regularly accepted in daily life outside work.

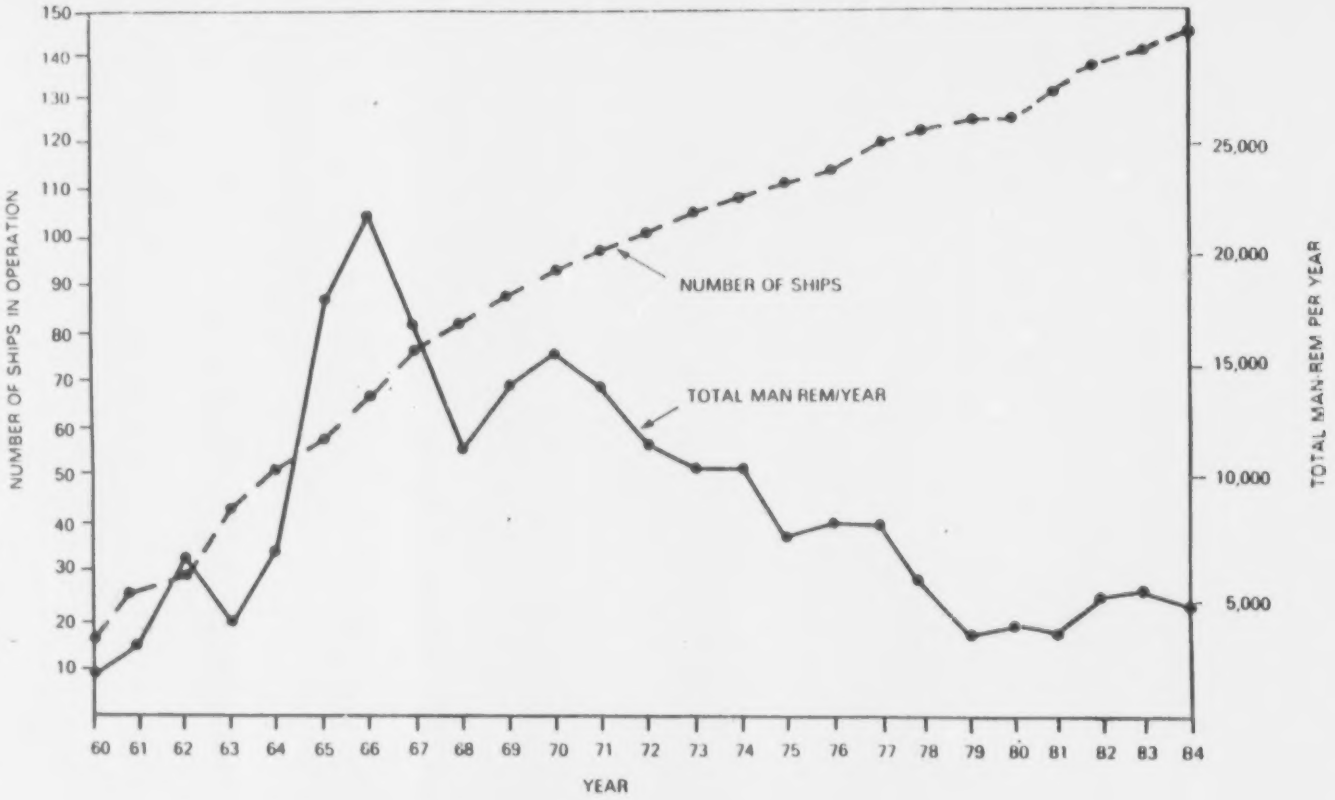


FIGURE 1
TOTAL RADIATION EXPOSURE RECEIVED BY MILITARY AND CIVILIAN PERSONNEL IN THE NAVAL NUCLEAR PROPULSION PROGRAM 1960-1984

EXTERNAL RADIATION EXPOSURE

Policy and Limits

The policy of the U. S. Navy is to reduce as low as reasonably achievable, exposure to personnel from ionizing radiation associated with Naval nuclear propulsion plants.

The radiation exposure limits used in the U. S. and abroad for whole body radiation exposure are 3 rem per quarter year and 5 rem accumulated dose for each year beyond age eighteen. These limits were recommended in 1958 by the U. S. National Committee ("Committee" was changed to "Council" when the organization was chartered by the U. S. Congress in 1964) on Radiation Protection and Measurements (ref 1) and by the International Commission on Radiological Protection (ref 2). They were adopted by the U. S. Atomic Energy Commission (AEC) and applied both within the AEC and to licensees in 1959 (ref 3). The U. S. Federal Radiation Council recommendation that these be used as guidance for Federal agencies was approved by President Eisenhower May 13, 1960 (ref 4). The U. S. Department of Labor adopted these same limits. A key part of each of these standards has been emphasis on minimizing radiation exposure to personnel.

In 1965 the International Commission on Radiological Protection (ref 5) reiterated the quarterly and accumulated limits cited above but suggested that exceeding 5 rem in one year should be infrequent. Although none of the other organizations referred to above changed its recommendations accordingly, the Naval Nuclear Propulsion Program adopted 5 rem per year as a rigorous limit effective in 1967.

In 1971 the National Council on Radiation Protection and Measurements (ref 6) recommended that 5 rem be adopted as the annual limit under most conditions. In 1974 the Atomic Energy Commission (now Department of Energy) (ref 7) established 5 rem as its annual limit. In 1977 the International Commission on Radiological Protection (ref 8) deleted the accumulated limit and recommended 5 rem as the annual limit. In 1979 the Nuclear Regulatory Commission issued a proposed change to the Code of Federal Regulations Title 10, Part 20 to require its licensees to use 5 rem as an annual limit. In January 1981, the Environmental Protection Agency recommended that Federal agencies use 5 rem as an annual limit (ref 9).

The Navy limits for the nuclear propulsion program since 1967 have been:

3 rem per quarter year
5 rem per year

.....
References are listed on pages 48 through 50.

Special limits are in effect such as for hands and feet; however, there have been few cases where these limits have been more restrictive than the whole body radiation exposure limits. Therefore, the radiation exposures discussed in this report are nearly all from whole body radiation. Controls are also in effect to minimize any occupational radiation exposure to the unborn child of a pregnant worker.

Each organization in the Naval Nuclear Propulsion Program is required to have an active program to reduce radiation exposure to the minimum practicable.

Source of Radiation

The radiation discussed in this report originates from pressurized water reactors. Water circulates through a closed piping system to transfer heat from the reactor core to a secondary steam system isolated from the reactor cooling water. Trace amounts of corrosion and wear products are carried by reactor coolant from reactor plant metal surfaces. Some of these corrosion and wear products are deposited on the reactor core and become radioactive from exposure to neutrons. Reactor coolant carries some of these radioactive products through the piping systems where a portion of the radioactivity is removed by a purification system. Most of the remaining radionuclides transported from the reactor core deposit in the piping systems.

The reactor core is installed in a heavy-walled pressure vessel within a primary shield. This shield limits radiation exposure from the gammas and neutrons produced when the reactor is at power. Reactor plant piping systems are installed primarily inside a reactor compartment which is surrounded by a secondary shield. Access to the reactor compartment is permitted only after the reactor is shut down. Most radiation exposure to personnel comes from inspection, maintenance and repair inside the reactor compartment. The major source of this radiation is cobalt 60 deposited inside the piping systems. Cobalt 60 emits two high energy gammas and a low energy beta for every radioactive decay. Its half-life is 5.3 years.

Neutrons produced when reactor fuel fissions are shielded by both primary and secondary shields before penetrating to occupied areas. Radiation exposure to personnel from these neutrons during reactor operation has been much less than from gammas. After reactor shutdown, when shipyard and other support facility work is done, no neutron exposure is detectable. As a result, the radiation exposures discussed in this report are nearly all from gamma radiation.

Control of Radiation During Reactor Plant Operation

Reactor plant shielding is designed to minimize radiation exposure to personnel. Shield design criteria establishing radiation levels in various parts of each nuclear-powered ship are personally approved by the Director of the Naval Nuclear Propulsion Program.

Ship design is also controlled to keep locations, such as duty stations where personnel need to spend time, as far as practicable away from the reactor compartment shield. Special attention is paid to living quarters. For example, the shield design criteria were established such that a person would have to spend more than 48 hours per day in living quarters to exceed exposure limits (which is impossible since there are only 24 hours in a day).

Resulting radiation exposure to those aboard ship outside propulsion plant spaces during reactor plant operation is not any greater than natural background radiation. For submarine operating personnel outside the propulsion plant, the combination of low natural radioactivity in ship construction materials and reduced cosmic radiation under water results in less radiation exposure from the nuclear reactor at sea than the public receives from natural background sources ashore. Those who operate the nuclear propulsion plant receive more radiation exposure in port during maintenance and overhaul periods than they receive from operating the propulsion plant at sea.

Control of Radiation in Support Facilities

Tenders for nuclear-powered submarines and surface ships are designed so that radioactive material is handled only in specially designed and shielded nuclear support facilities. Submarine bases and shipyards limit to the minimum, the number of places where radioactive material is allowed. Specific traffic routes are required to be used for any movement of radioactive material outside these nuclear support facilities. A radioactive material accountability system is used to ensure no radioactive material is lost or misplaced in a location where personnel could unknowingly be exposed. Regular inventories are required for every item in the radioactive material accountability system. Radioactive material is tagged with yellow and magenta tags bearing the standard radiation symbol and the measured radiation level. Radioactive material removed from a reactor plant is required to be placed in yellow plastic, and the use of yellow plastic is reserved solely for radioactive material. All personnel assigned to a tender, submarine base or shipyard are trained to recognize that yellow plastic identifies radioactive material and to initiate immediate action if radioactive material is discovered out of place.

Access to radiation areas is controlled by radiological control personnel. Personnel are required to wear dosimetry devices to enter these areas. Dosimetry devices are also posted on the boundaries of these areas to verify that personnel outside these areas do not require monitoring. Frequent radiation surveys are required using instruments which are checked before use and calibrated regularly. Areas where radiation levels are greater than 0.1 rem per hour are called high radiation areas and are locked or guarded.

Dosimetry

Thermoluminescent dosimeters (TLD's) are the dosimetry devices worn by personnel to measure their exposure to gamma radiation. The thermoluminescent dosimeter contains two chips of calcium fluoride with added manganese. It is characteristic of thermoluminescent material that radiation causes internal changes which make the material, when subsequently heated, give off an amount of light directly proportional to the radiation dose. In order to make it convenient to handle, these chips of calcium fluoride are in contact with a metallic heating strip with heater wires extending through the ends of a surrounding glass envelope. The glass bulb is protected by a plastic case designed to permit the proper response to gammas of various energies. Gammas of such low energy that they will not penetrate the plastic case constitute less than a few percent of the total gamma radiation present. To read the radiation exposure, a trained operator removes the glass bulb and places it in a TLD reader so that the metal heater wires contact an electrical circuit. An electronically controlled device heats the calcium fluoride chips to several hundred degrees centigrade in a timed cycle, and the intensity of light emitted is measured and converted to a digital readout in units of rem. The heating cycle also anneals the calcium fluoride chips so that the dosimeter is zeroed and ready for subsequent use. The entire cycle of reading a TLD described here takes about thirty seconds. This rapid readout capability was one reason for changing from film badges to TLD's. The use of TLD's permits more frequent measurement of a worker's radiation exposure than film badges. TLD's are required to be processed at least daily in Naval shipyards. Aboard ship, TLD's are required to be processed at least monthly except that daily processing is required for anyone entering a reactor compartment or high radiation area.

To ensure accuracy of the TLD system, several periodic calibration and accuracy checks are performed. For example, TLD's are checked when new and once every six months thereafter for accurate response to a known radiation exposure. Those that fail are discarded or repaired. TLD readers are calibrated once each year to verify accuracy by one of several calibration facilities having precision radiation sources and precision TLD standards. In addition, weekly, daily and hourly checks of proper TLD reader operation and accuracy are performed when readers are in use utilizing internal electronic standards built into each reader.

In addition to these calibrations and checks, the Navy has an independent dosimetry quality assurance program to monitor the accuracy of TLD's and TLD readers in use at program activities. Precision TLD's are pre-exposed to exact amounts of radiation by the National Bureau of Standards and provided to program activities for reading. The activity's results are then compared to the actual exposures. A random sample of dosimeters in use at the activity being tested is also selected and sent to a Navy shore facility for accuracy testing. To assure objectivity, the activity being tested is not told of the radiation values to which the dosimeters have been exposed and is not permitted to participate in the selection of the dosimeter sample. Any inaccuracies found by these tests that exceed established permissible error bands result in appropriate corrective action such as recalibration of a failed TLD reader. The results of this program demonstrate that the radiation to which personnel are exposed is being measured by the TLD system with an average error of less than 10%.

Pocket ionization chambers with an eyepiece permit the wearer to read his own radiation exposure. This pocket dosimeter is required in addition to a TLD when entering a reactor compartment or a high radiation area. Pocket dosimeters are used to enable the wearer to keep track of his own radiation exposure during a work period. The official record of radiation exposure is obtained from the TLD.

Dosimetry devices are worn on the trunk of the body, normally at the waist or chest, whichever will receive the higher exposure. In some special situations dosimeters are worn at other locations, for example on the hands or fingers or head.

In 1974, the conversion from film badges to TLD's for measuring radiation exposure was completed. Prior to this time film packets like those used for dental X-ray were placed in holders designed to allow differentiating between types of radiation. The darkness of the processed film was measured with a densitometer and converted to units of radiation exposure. When the first personnel radiation exposures were measured in the Naval Nuclear Propulsion Program, there already was widespread photodpsimetry experience in the Navy and precise procedures existed to provide reproducible results.

Each film badge was clearly marked with a name or number corresponding to the individual to whom it was assigned. This number was periodically checked by a radiological control technician before a worker entered a high radiation area. In high radiation areas every worker also wore a pocket dosimeter which was read by radiological control personnel when the worker left the area. At the end of each month when the film badges were processed, the film badge measurements were compared with the sum of the pocket dosimeter readings. The film badge results were, with few exceptions, entered in the permanent personnel radiation exposure records.

Discrepancies between film badge and pocket dosimeter measurements were investigated. These investigations included making independent estimates of the worker's exposure using such methods as time spent in the specific radiation area and comparing the estimates with the two measurements to determine which measurement was in error. If the error could not be determined, then the higher exposure was recorded for the worker. In nearly all cases this was the film badge measurement.

Results of numerous tests conducted by shipyards under the same conditions that most radiation exposure was received showed that film measurements averaged fifteen percent higher than actual radiation exposures. This was a conscious conservatism to ensure that under the worst case, the film measurement was not less than the actual radiation exposure. Film response varies with the energy of the gamma radiation. The calibration of the film was performed at high energy where the film has the least response to radiation exposure. Radiation of lower energies corresponding to scattered radiation from shielded cobalt 60 causes the film to indicate more radiation exposure than is present.

Data gathered in over 20 years of neutron monitoring aboard ships using neutron film badges demonstrated that the monitored individuals did not receive neutron exposure above the minimum detection level for neutron film. Naval nuclear-powered ships and their support facilities now use lithium fluoride TLD's to monitor neutron exposure of the few personnel exposed to neutron sources such as for radiation instrument calibration and for reactor plant instrumentation source handling. These measured neutron exposures have been added to gamma exposures in the total whole body radiation exposure in this report, but because neutron exposures are so low, the radiation exposures in this report are nearly all from gamma radiation.

Monitoring for beta radiation is not normally required because betas cannot penetrate the metal boundaries of the reactor coolant system. Beta radiation needs to be considered in maintenance or repair operations only when systems are opened so that personnel are close to surfaces which have been contaminated with radioactive corrosion products from reactor coolant. In these cases normal clothing or eyeglasses or plastic contamination control materials completely shield beta radiation of the energies normally present. Support facilities routinely provide such shielding to eliminate personnel radiation exposure from betas.

Monitoring for alpha radiation is not a normal part of operation or maintenance of Naval nuclear propulsion plants. However, alpha monitoring is sometimes necessary to identify radium daughter products naturally present in the atmosphere.

Physical Examinations

Radiation medical examinations have been required since the beginning of the Naval Nuclear Propulsion Program for personnel exposed to radiation. These examinations are conducted in accordance with the Navy's Radiation Health Protection Manual (ref 10). In these examinations the doctor pays special attention to any condition which might indicate that radiation exposure would cause an increased degree of risk. Passing this examination is a prerequisite for obtaining the dosimetry badge which permits entry to areas where radiation exposure can be received. For military personnel who have already been screened by physical examinations, few fail this radiation medical examination. For civilian shipyard workers, the failure rate is a few percent. However, failure of this examination does not mean a shipyard worker will not have a job. Since shipyard workers spend most of their time on non-radioactive work, inability to qualify for radioactive work does not restrict their job opportunities. No shipyard worker in the Naval Nuclear Propulsion Program has been fired for inability to pass a radiation medical examination.

Radiation medical examinations are given prior to initial radiation work, periodically thereafter (at least every three years), and at termination of radioactive work in the nuclear propulsion program (or at termination of employment).

A radiation medical examination includes review of medical history to determine, among other subjects, past radiation exposure, history of cancer, history of radiation therapy, and family history of cancer. In the medical examination particular attention is paid to evidence of cancer. Laboratory procedures include urinalysis, blood analysis, and comparison of blood constituents to a specific set of standards. Chest X-rays with full size film to reduce radiation exposure were also a routine part of all radiation medical examinations until 1977. At that time routine chest X-rays were discontinued, further reducing radiation exposure of workers. Chest X-rays are now performed when clinically indicated at the discretion of the medical officer. In the event disqualifying conditions are found in an examination of Naval civilian or military personnel, the individual is barred from receiving occupational radiation exposure and the results of the examination are reviewed by the Naval Medical Command Radiation Effects Advisory Board. Only after approval of the Board would the individual be permitted to receive occupational radiation exposure.

Shipyard, Tender, and Submarine Base Training

Periodic radiological control training is performed to ensure each person understands the general and specific radiological aspects which he might encounter, understands his responsibility to the Navy and the public for safe handling of radioactive materials, understands the risks associated with radiation exposure and understands his responsibility to minimize his own radiation exposure. Training is also provided on the biological risk of radiation exposure to the unborn child. Prior to being authorized to perform radioactive work, an employee is required to complete satisfactorily a radiological control training course, including a written examination. Typical course lengths for workers range from 16 to 32 hours. In written examinations on radiological controls, short answer questions, such as multiple choice and true-false questions, are not normally used. The following are the minimum training requirements for workers:

1. Radiation Exposure Control

   a. State the limits for whole body penetrating radiation. Explain that the rem is a unit of biological dose from radiation.

   b. Explain how "stay times" are used.

   c. Be aware of the seriousness of violating instructions on radiation warning signs and unauthorized passage through barriers.

   d. Discuss procedures and methods for minimizing exposure such as working at a distance from a source, reducing time in a radiation area, and shielding.

   e. Discuss potential sources of radiation associated with work performed by the individual's trade.

   f. State where dosimetry equipment shall be placed on an individual's body.

   g. Demonstrate ability to read all types of dosimeters in use.

   h. Discuss importance of the individual keeping track of his own exposure.

   i. Be aware of the significance of personnel radiation exposure. The National Council on Radiation Protection and Measurements has stated that while exposures of workers and the general population

should be kept to the lowest practicable level at all times, the presently permitted exposures represent a level of risk small compared with other hazards of life. The Nuclear Regulatory Commission has stated, "Control of exposure to radiation is based on the assumption that any exposure, no matter how small, involves some risk." The risk of injury from radiation associated with Naval nuclear propulsion plants is low compared to the occupational and nonoccupational risks accepted in everyday life.

2. Contamination Control

a. Discuss how contamination is controlled during radioactive work (e.g., containment in plastic bags and use of contamination containment areas).

b. Discuss procedures for preventing contamination of personnel and how contamination is detected on personnel.

c. Discuss how contamination is removed from contaminated objects and personnel.

d. Discuss potential sources of contamination associated with work performed by the individual's trade.

e. State the beta-gamma surface contamination limit. Discuss the meaning of the units of the limit.

f. Demonstrate proper procedure for donning and removing a full set of an icontamination clothing.

g. Demonstrate proper procedures for entering and leaving a contaminated area including proper procedures for self-monitoring.

h. Explain what radioactive contamination is. Explain the difference between radiation and radioactive contamination.

i. For personnel required to work in containment areas (e.g., glove bags or tents), demonstrate proper procedures for working in these areas. (This ability is often demonstrated on a mock-up.)

54-230 O - 86 - 6

j. For personnel who are likely to encounter airborne radioactivity, demonstrate the proper procedure for donning and removing the type of respiratory equipment the individual will be required to wear. For personnel who are required to wear respiratory equipment with anticontamination clothing, this demonstration shall be performed when donning and removing anticontamination clothing. The demonstration shall include any leak checks required to be made to test for proper operation of respiratory equipment.

k. For personnel who are likely to encounter airborne radioactivity, state the conditions which require wearing masks, air supplied respirators, or air supplied hoods.

3. Accountability of Radioactive Materials - Know that radioactive materials are accounted for when transferred between radiologically controlled areas by tagging, by recording disposition of material, and by specific authorization of radiological control personnel.

4. Waste Disposal - Discuss how individual workers can reduce the amount of radioactive liquid and solid waste.

5. Radiological Incidents

a. Discuss the need for consulting radiological control personnel when questions or incidents occur.

b. Discuss procedures to be followed after a spill of material (liquid or solid) which is or might be radioactive.

c. Discuss procedures to be followed when notified that airborne radioactivity is above the limit.

d. Demonstrate the action to be taken in event of a spill of radioactive liquid. This ability shall be demonstrated during a drill.

e. Discuss the action to be taken when an individual discovers his dosimeter is off-scale.

6. Responsibilities of Individuals - Discuss actions required in order to fulfill workers' responsibilities. Include the responsibility of the individual to inform his employer of previous or concurrent occupational radiation exposure received.

In addition to passing a written examination, completion of this training course requires satisfactory performance during basic types of simulated work operations. For an employee to continue as a radiation worker, he has to requalify in a manner similar to the initial qualification at least every two years. In between these qualification periods, personnel are required to be selected at random for additional written and practical work operation examinations to determine how well the knowledge and abilities have been retained. Training is also conducted by individual shop instructors in the specific job skills for radiation work within each trade. For complex jobs this is followed by special training for the specific job, frequently using mock-ups outside radiation areas.

Radiological control technicians are required to complete a course of six months to one year in length in radiological controls, to demonstrate their practical abilities in work operations and drills and to pass comprehensive written and oral examinations. Radiological control supervisors are required to have at least the same technical knowledge and abilities as the technicians; however, passing scores for supervisors' examinations are higher or supervisors' examinations are more difficult than for technicians. Oral examinations are conducted by senior radiological control managers and require personnel to be able to evaluate symptoms of unusual radiological control situations. The radiological control technician or supervisor is required to evaluate initial symptoms, state immediate corrective action required, state what additional measurements are required, and do a final analysis of the measurements to identify the specific problem. Subsequent to qualification, periodic training sessions are required in which each radiological control technician and supervisor demonstrates ability to handle situations such as are used in the oral examinations. At least every two and a half years, radiological control personnel have to requalify through written and oral examinations similar to those used for initial qualification. Radiological control technicians and supervisors are required to demonstrate their practical abilities frequently through unannounced drills.

In addition to the above training for those who are involved in radioactive work, each shipyard employee not involved in radioactive work and each person assigned to a nuclear-powered ship or a support facility is required to receive basic radiological training which is repeated at least annually. This training is to ensure personnel understand the posting of radiation areas, the identification of radioactive materials, and not to cross radiation barriers. This instruction also explains that the radiation environment of personnel outside radiation areas and outside the ship or shipyard is not significantly affected by nuclear propulsion plant work.

Nuclear Power Training

Military personnel who operate Naval nuclear propulsion plants are required to pass a six month basic training course at nuclear power school and a six month qualification course at a land-based prototype of a shipboard reactor plant. Each nuclear-trained officer and enlisted man receives extensive radiological control training including lectures, demonstrations, practical work, radiological control drills and written and oral examinations. This training has emphasized the ability to apply basic information on radiation and radioactivity.

Those enlisted personnel who will have additional responsibilities for radiological control associated with operation of nuclear propulsion plants are designated Engineering Laboratory Technicians and receive an additional three months training after completion of the one year program. Engineering Laboratory Technicians and other selected nuclear trained personnel who are assigned radiological control duties at tenders and submarine bases normally receive an additional intensive one month training program in the practical aspects of radiological controls associated with maintenance and repair work.

Prior to becoming qualified as the Engineer Officer, that is, the head of the engineering department of a nuclear-powered ship, a nuclear-trained officer must pass a one day written examination and a sequence of oral examinations conducted at the Naval Nuclear Propulsion Program headquarters. A key part of these qualification examinations is radiological controls.

Immediately before serving as Commanding Officer of a nuclear-powered ship, an officer attends a three month course at the Naval Nuclear Propulsion Program headquarters. The radiological controls portion of this is an advanced course and assumes the officer starts with detailed familiarity with shipboard radiological controls. The officer must pass both written and oral examinations in radiological controls during this course prior to assuming command of a nuclear-powered ship.

Radiation Exposure Reduction

Maintaining personnel radiation exposures as low as reasonably achievable involves all levels of management in nuclear-powered ships and their support facilities. Operations, maintenance and repair personnel are required to be involved in this subject; it is not left solely to radiological control personnel. To evaluate the effectiveness of radiation exposure reduction programs, managers use a set of goals. Goals are also set in advance to keep each worker's exposure under certain levels and to minimize the number of workers involved. Goals are also set on the total cumulative personnel radiation exposure (man-rem) for each major job, for the entire overhaul or maintenance period, and for the whole year. These goals are deliberately made hard to meet in order to encourage personnel to improve performance.

Of the various goals used, the most effective in reducing personnel radiation exposure has been the use of exposure control levels which are lower than the Navy's quarterly and annual limits. Control levels in shipyards range from 0.5 rem to 2 rem for the year, depending on the amount of radioactive work scheduled, whereas 5 rem per year is the annual Navy limit.

To achieve the benefits of lower control levels in reducing total man-rem, it is essential to minimize the number of workers permitted to receive radiation exposure. Otherwise the control levels could be met merely by adding more workers. Organizations are required to conduct periodic reviews to ensure the number of workers is the minimum for the work that has to be performed.

The following is a synopsis of the checklist which has been in use for years in maintaining personnel radiation exposure as low as reasonably achievable during maintenance, overhaul, and repair.

Preliminary Planning

- Plan in advance
- Delete unnecessary work
- Determine expected radiation levels

Preparation of Work Procedures

- Plan access to and exit from work area
- Provide for service lines (air, welding, ventilation, etc.)
- Provide communication (sometimes includes closed-circuit television)
- Remove sources of radiation
- Plan for installation of temporary shielding
- Decontaminate
- Work in lowest radiation levels
- Perform as much work as practicable outside radiation areas
- State requirements for standard tools
- Consider special tools
- Include inspection requirements (these identify steps where radiological control personnel must sign prior to work proceeding)
- Minimize discomfort of workers
- Estimate man-rem

Temporary Shielding

- Control installation and removal by written procedure
- Inspect after installation
- Conduct periodic radiation surveys
- Minimize damage caused by heavy lead temporary shielding
- Balance radiation exposure received in installation against exposure to be saved by installation
- Shield travel routes
- Shield components with abnormally high radiation levels early in the maintenance period
- Shield position worker occupies
- Perform directional surveys to improve design of shielding by locating sources of radiation
- Use mock-up to plan temporary shielding design and installation

Rehearsing and Briefing

- Rehearse
- Use mock-up duplicating working conditions
- Use photographs
- Brief workers

Performing Work

- Post radiation levels
- Keep excess personnel out of radiation areas
- Minimize beta radiation exposure (anticontamination clothing effectively shields cobalt 60 betas)
- Supervisors and workers keep track of radiation exposure
- Workers assist in radiation and radioactivity measurements
- Delegate radiological control monitoring responsibilities when necessary to minimize radiation exposure
- Evaluate use of fewer workers
- Reevaluate reducing radiation exposures

Additional measures that have been taken to reduce exposure include standardization of procedures, development of new tooling, improved use of temporary shielding, and compliance with strict contamination control measures. For example, most work involving radioactive contamination is performed in total containment. This practice minimizes the potential for spreading contamination and thus reduces work disruptions, simplifies working conditions and minimizes the cost and exposure to clean up.

Lessons learned during radioactive work and new ways to reduce exposure developed at one organization are made available for use by other organizations in the Naval Nuclear Propulsion Program. This effort allows all of the organizations to take advantage of the experience and developments at one organization and minimizes redundant effort.

The extensive efforts that have been taken to reduce exposure in the Naval Nuclear Propulsion Program have also had unplanned benefits, such as reduced cost to perform radioactive work and improved reliability. Efforts such as detailed work planning, rehearsing, total containment, special tools and standardization have resulted in increased efficiency and better access to perform maintenance with the overall result that reliability is improved and costs are reduced.

Radiation Exposure Data

Radioactive materials had been handled in shipyards for years before Naval nuclear propulsion plant work started. Examples of such work include non-destructive testing using radiography sources and radiation instrument calibration using radioactive sources. Since this work is licensed by the Nuclear Regulatory Commission or by a state under agreement with the Nuclear Regulatory Commission, the radiation exposure from this licensed work has been excluded whenever practicable from this report.

Table 1 shows the dates when radioactive work associated with Naval nuclear propulsion plants started in each of eleven shipyards. Seven of these shipyards have constructed Naval nuclear-powered ships; however, little radiation exposure is received in new construction. The dates of starting reactor plant overhaul, therefore, are the significant dates for start of radioactive work.

The total occupational radiation exposure received by all personnel in the Naval Nuclear Propulsion Program in 1984 was 4,898 man-rem. Table 2 summarizes radiation exposure received in nuclear-powered ships and their supporting tenders and submarine bases since the first nuclear-powered ship went to sea in January 1955. Most of the radiation exposure in this table results from inspection, maintenance and repair work in the reactor compartments of ships. In general, radiation exposures for reactor compartment work increase as reactor plant radiation levels increase with the age of the plant.

As expected, the number of personnel monitored for exposure to radiation increased with the increasing number of nuclear-powered ships. Initially, everyone aboard a nuclear-powered submarine was monitored for occupational radiation exposure. After years of experience showed that personnel outside propulsion plant spaces received exposures indistinguishable from natural background, the number of personnel monitored for occupational exposure to radiation from the propulsion plant was

sharply reduced in 1974. For example, in 1973 almost sixty percent of those monitored were recorded as receiving zero radiation exposure; as a result of reducing numbers of personnel monitored unnecessarily, less than ten percent of those monitored for occupational exposure are now recorded with zero exposure. Personnel outside propulsion plant spaces in submarines now wear dosimetry badges to verify they do not receive occupational exposure from the propulsion plant.

Table 3 summarizes radiation exposures of shipyard personnel since the start of Naval nuclear propulsion plant radioactive work in 1954. Figure 2 shows graphically that total personnel radiation exposure has been reduced in shipyards even though the amount of work has increased. Since ship overhauls frequently overlapped calendar years, the numbers of ships in overhaul shown in Figure 2 were determined by dividing by 12 the total number of months each ship was in overhaul during a calendar year.

The increase in the numbers of personnel monitored and total man-rem exposure in the early years shows the increasing workload in reactor plant work as the number of ships increased. By 1962 four submarine reactor plants had been overhauled and major efforts were underway to reduce radiation levels. By 1966 the number of ships in overhaul had quadrupled as indicated by the buildup to the peak in total man-rem. Subsequently, the number of ships in overhaul more than doubled again. Decreases in total annual exposures, numbers of personnel monitored, and numbers of personnel with annual exposures over 2 rem have been as a result of the program to reduce radiation exposures to the minimum practicable. The total annual exposure for the shipyards has averaged less than 6000 man-rem and for ships has averaged less than 2000 man-rem.

Since a worker usually is exposed to radiation in more than one year, the total number of personnel monitored cannot be obtained by adding the annual numbers. The total number of shipyard personnel monitored for radiation exposure associated with the Naval Nuclear Propulsion Program has been about 126,000. Nearly all of these are civilians, about half of whom are U. S. Government employees at six Naval shipyards. Table 4 provides further information about the distribution of their radiation exposures. In 1984, about 91 percent of those monitored for radiation in shipyards and about 99 percent of those in ships received less than 0.5 rem in a year, the limit allowed by Federal regulations for a member of the general public. The average exposure per year for each person monitored has been 0.31 rem in shipyards, which is less than one tenth the occupational exposure limit. The average exposure per year for those monitored in ships has been 0.11 rem, which is less than the average annual exposure a person receives from natural background and medical radiation.

Table 4 also lists the numbers of personnel who have exceeded the 3 rem quarterly exposure limit. In no case have personnel exceeded the accumulated limit of 5 rem for each year of age over eighteen. The total number of persons who have exceeded the quarterly limit since the limit was imposed in 1959 is 37, of whom 4 were military personnel aboard ships. Thirty of the 37 personnel had quarterly exposures in the range of 3 to 4 rem, and the highest exposure was 9.7 rem in a quarter. Navy procedures require any person who receives greater than 25 rem in a short time period to be placed under medical observation. None of the exposures reached this level.

The average lifetime accumulated exposure from radiation associated with Naval nuclear plants for all shipyard personnel is 1.3 rem. Since the average annual exposure per person is 0.31 rem, this means that the average shipyard radiation worker is monitored because of Naval nuclear propulsion plant work for about four years. The average lifetime accumulated exposure for the 61,900 Naval officers and enlisted men trained to operate a nuclear propulsion plant is about 0.9 rem. These radiation exposures are much less than the exposure the average American receives from medical diagnostic X-rays during his working lifetime.

TABLE 1

SHIPYARD FIRST REACTOR PLANT OPERATION
AND FIRST RADIOACTIVE OVERHAUL WORK

Shipyard	Year First New Construction Reactor Started Operation	Year First Reactor Plant Overhaul Started
Electric Boat Division* Groton, Connecticut	1954	1957
Portsmouth Naval Shipyard Portsmouth, New Hampshire	1958	1959
Mare Island Naval Shipyard** Vallejo, California	1958	1962
Pearl Harbor Naval Shipyard Pearl Harbor, Hawaii	None	1962
Charleston Naval Shipyard** Charleston, South Carolina	None	1963
Newport News Shipbuilding Newport News, Virginia	1960	1964
Bethlehem Steel Shipbuilding*** (Subsequently Electric Boat Division) Quincy, Massachusetts	1961	None
New York Shipbuilding Corporation*** Camden, New Jersey	1963	None
Norfolk Naval Shipyard Portsmouth, Virginia	None	1965
Puget Sound Naval Shipyard** Bremerton, Washington	None	1967
Ingalls Shipbuilding Division*** Pascagoula, Mississippi	1961	1970

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* Electric Boat Division performed overhauls in 1957-1977 but only did new construction work again starting in 1978.

** Radioactive work of less extent than in an overhaul commenced in Mare Island in 1958, in Charleston in 1961, and in Puget Sound in 1965.

*** Work on Naval nuclear-powered ships was discontinued at Camden, New Jersey in 1967, at Quincy, Massachusetts in 1969, and at Pascagoula, Mississippi in 1980.

TABLE 2
OCCUPATIONAL RADIATION EXPOSURE RECEIVED BY PERSONNEL ASSIGNED TO TENDERS, BASES, AND NUCLEAR-POWERED SHIPS FROM OPERATION AND MAINTENANCE OF NAVAL NUCLEAR PROPULSION PLANTS

	Number of Persons Monitored Who Received Exposures in the Following Ranges of Rem for the Year						Total Personnel Monitored	Total Man-Rem
Year	0-1	1-2	2-3	3-4	4-5	5*		
1954	36	0	0	0	0	0	36	8
1955	90	11	0	0	0	0	101	25
1956	108	10	4	0	0	0	122	50
1957	293	7	1	0	0	0	301	60
1958	562	11	3	0	0	0	576	100
1959	1,057	41	8	3	0	0	1,109	200
1960	2,607	88	8	4	3	1	2,711	375
1961	4,812	106	31	4	4	0	4,957	680
1962	6,788	182	75	31	17	1	7,094	1,312
1963	9,188	197	39	14	3	1	9,442	1,420
1964	10,317	331	93	35	15	4	10,795	1,964
1965	11,883	592	224	96	30	24	12,849	3,421
1966	18,118	541	156	95	44	28	18,982	3,529
1967	21,028	339	139	48	11	0	21,565	3,084
1968	24,200	373	103	20	2	0	24,698	2,463
1969	26,969	577	127	39	6	0	27,718	2,918
1970	26,206	610	134	30	0	0	26,980	3,089
1971	26,090	568	122	31	2	0	26,813	3,261
1972	33,312	602	180	13	1	0	34,108	3,271
1973	30,852	600	102	15	1	0	31,570	3,160
1974	18,375	307	65	2	0	0	18,749	2,142
1975	17,638	330	28	1	0	0	17,997	2,217
1976	17,795	369	56	9	0	0	18,229	2,642
1977	20,236	346	95	36	3	0	20,716	2,812
1978	22,089	290	23	1	0	0	22,403	2,234
1979	21,121	75	1	0	0	0	21,197	1,528
1980	21,767	78	0	0	0	0	21,845	1,494
1981	23,781	27	0	0	0	0	23,808	1,415
1982	27,563	59	0	0	0	0	27,622	1,660
1983	27,593	52	0	0	0	0	27,645	1,832
1984	30,096	10	0	0	0	0	30,106	1,717

Note: Data obtained from summaries rather than directly from original medical records. Total man-rem was determined by adding actual exposures for each individual monitored by each reporting command during the year. Total number monitored includes visitors to each reporting command. It is expected that the large effort to compile comparable man-rem data from original medical records would show differences no greater than five percent.

* Limit in the Naval Nuclear Propulsion Program was changed to 5 rem per year in 1967

TABLE 3
OCCUPATIONAL RADIATION EXPOSURE RECEIVED BY SHIPYARD PERSONNEL
FROM WORK ASSOCIATED WITH NAVAL NUCLEAR PROPULSION PLANTS

	Number of Persons Monitored Who Received Exposures in the Following Ranges of Rem for the Year						Total Personnel Monitored	Total Man-Rem
Year	0-1	1-2	2-3	3-4	4-5	5*		
1954	508	9	3	5	3	0	528	64
1955	2,563	80	25	6	3	2	2,679	344
1956	2,834	20	5	2	0	1	2,862	162
1957	3,473	97	31	1	2	4	3,608	495
1958	5,766	165	46	10	4	7	5,998	779
1959	10,388	221	133	78	49	23	10,892	1,864
1960	12,047	198	97	22	4	0	12,368	1,158
1961	13,383	198	91	44	14	3	13,733	1,241
1962	14,411	642	366	247	146	108	15,920	5,222
1963	19,164	446	159	71	34	28	19,902	2,725
1964	24,044	804	445	215	144	41	25,693	5,678
1965	22,630	2,306	1314	814	618	525	28,207	15,829
1966	29,490	2,352	1,623	1,057	1,139	513	36,174	18,804
1967	29,853	2,388	1,563	1,096	733	1	35,634	13,908
1968	30,159	1,344	773	496	279	0	33,051	8,719
1969	25,672	1,790	1,080	753	375	0	29,670	11,077
1970	21,182	2,127	1,382	740	492	0	25,923	13,084
1971	20,041	1,928	1,066	650	240	0	23,925	10,616
1972	17,514	1,692	849	139	5	0	20,199	7,002
1973	13,036	1,403	604	203	6	0	15,252	6,083
1974	12,587	1,464	745	311	50	0	15,157	7,206
1975	12,825	1,116	598	82	42	0	14,663	5,285
1976	13,042	1,268	633	30	0	0	14,973	5,310
1977	13,835	1,277	586	25	0	0	15,723	5,199
1978	13,700	1,016	268	0	0	0	14,984	3,680
1979	15,032	227	7	0	0	0	15,266	2,024
1980	15,287	377	0	0	0	0	15,664	2,402
1981	17,414	304	0	0	0	0	17,718	2,310
1982	19,210	648	0	0	0	0	19,858	3,353
1983	20,407	714	0	0	0	0	21,121	3,506
1984	20,684	502	0	0	0	0	21,186	3,181

NOTE: Data obtained from summaries rather than directly from original medical records. Total man-rem was determined by adding actual exposures for each individual monitored by each shipyard during the year. Total number monitored includes visitors to each shipyard. It is expected that the large effort to compile comparable man-rem data from original medical records would show differences no greater than five percent.

*Limit in the Naval Nuclear Propulsion Program was changed to 5 rem per year in 1967.

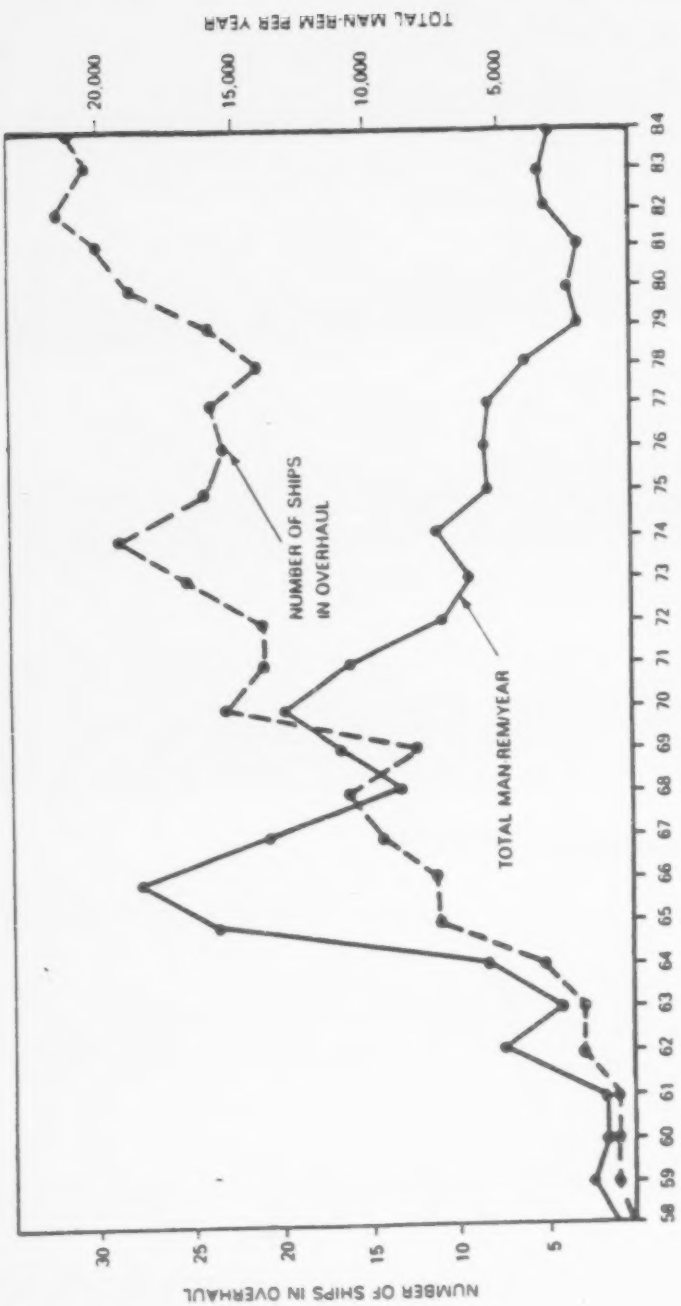

FIGURE 2
TOTAL RADIATION EXPOSURE RECEIVED BY SHIPYARD PERSONNEL
FROM WORK ASSOCIATED WITH NAVAL
NUCLEAR PROPULSION PLANTS 1958-1984

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TABLE 4
SHIPYARD AND FLEET DISTRIBUTION
OF PERSONNEL RADIATION EXPOSURE

Year	Average Rem Per Person Monitored		Percent of Personnel Monitored Who Received Greater Than 1 Rem		Number of Personnel Who Exceeded 3 Rem/Quarter
	Fleet	Shipyard	Fleet	Shipyard	
1954	.22	.12	0	3.8	0
1955	.25	.13	10.9	4.3	0
1956	.41	.06	11.5	1.0	0
1957	.20	.14	2.7	3.7	0
1958	.17	.13	2.4	3.9	0
1959	.18	.17	4.7	4.6	8
1960	.14	.09	7.5	2.6	0
1961	.14	.09	2.9	2.5	0
1962	.19	.33	4.3	9.5	9
1963	.15	.13	2.7	3.7	2
1964	.18	.22	4.4	6.4	4
1965	.27	.56	7.5	19.8	5
1966	.19	.52	4.6	18.5	6
1967	.14	.39	2.5	16.2	3
1968	.10	.26	2.0	8.8	0
1969	.11	.37	2.7	13.5	0
1970	.11	.50	2.9	18.3	0
1971	.12	.44	2.7	16.2	0
1972	.10	.35	2.3	13.3	0
1973	.10	.40	2.3	14.5	0
1974	.11	.48	2.0	17.0	0
1975	.12	.36	2.0	12.5	0
1976	.14	.35	2.4	12.9	0
1977	.14	.33	2.3	12.0	0
1978	.10	.24	1.4	8.5	0
1979	.07	.13	0.4	1.5	0
1980	.07	.15	0.4	2.4	0
1981	.06	.13	0.1	1.7	0
1982	.06	.17	0.2	3.3	0
1983	.07	.17	0.2	3.4	0
1984	.06	.15	0.0	2.4	0
Average	.11	.31	2.0	10.3	
NAVYWIDE AVERAGE	.21		6.3		

Table 5 provides information on the distribution of lifetime accumulated exposures for all personnel who were monitored in 1984 for radiation exposure associated with Naval nuclear propulsion plants. Federal radiation exposure limits allow accumulating 100 rem in twenty years of work, or 200 rem in forty years. The fact that no one shown in Table 5 comes close to having accumulated this much radiation exposure is the result of deliberate efforts to keep well below the lifetime accumulated radiation exposure limit.

TABLE 5
DISTRIBUTION OF TOTAL LIFETIME RADIATION EXPOSURE ASSOCIATED WITH NAVAL NUCLEAR PROPULSION PLANTS

RANGE OF ACCUMULATED LIFETIME RADIATION EXPOSURES (REM)	PERCENTAGE OF PERSONNEL MONITORED IN 1984 WITH LIFETIME ACCUMULATED RADIATION EXPOSURE IN THE RADIATION RANGE	
	FLEET	SHIPYARDS
0 - 5	99.01	85.72
5 - 10	0.94	7.12
10 - 15	0.04	3.28
15 - 20	0.01	1.98
20 - 25	0	0.99
25 - 30	0	0.66
30 - 50	0	0.25
Greater than 50	0	0.00

Table 6 provides a basis for comparison between the radiation exposure for light water reactors operated by the Navy and commercial power reactors licensed by the Nuclear Regulatory Commission. The 1983 data in this Nuclear Regulatory Commission table covers 77 licensees with a total of 56,471 man-rem (ref 11). The 1983 average annual exposure of each worker at commercial power reactors was 0.41 rem.* Licensees of commercial power reactors reported 260 overexposures to external radiation during the years 1971 through 1983. Numbers in excess of 5 rem are not necessarily overexposures since Nuclear Regulatory Commission regulations permit exposures of 3 rem each quarter up to 12 rem per year within the accumulated total limit of 5 rem for each year of a person's age beyond eighteen.

*This average was calculated by dividing total man-rem by total number of workers monitored as is done in Table 4. Ref (11) reports this value as 0.66; however, it is calculated by dividing the total man-rem by the number of workers with measurable exposure.

TABLE 6
PERSONNEL
RADIATION EXPOSURE FOR COMMERCIAL NUCLEAR-POWERED REACTORS LICENSED
BY U.S. NUCLEAR REGULATORY COMMISSION

SUMMARY OF ANNUAL WHOLE BODY EXPOSURE BY INCREMENT

			NUMBER OF INDIVIDUALS												
			EXPOSURE INCREMENT - REM												
YEAR	TOTAL MONITORED	NOT MEASURABLE	0-1	1-2	2-3	3-4	4-5	5-6	6-7	7-8	8-9	9-10	>10	TOTAL MAN-REM	NUMBER OF OVER-EXPOSURES
1969	2,838		2,607		134	65	25	5	2	0	0	0	0		
1970	7,509		6,985		166	163	88	98	8	1	0	0	0		
1971	9,581		8,996		315	137	105	17	11	0	0	0	0		2
1972	15,713		14,783		532	199	111	46	21	9	6	6	0		16
1973	33,823	19,043	9,798	2,468	1,584	422	251	71	38	16	7	0	0	13,963	19
1974	38,938	20,472	13,766	2,503	1,378	471	226	86	30	6	0	0	0	13,722	43
1975	44,343	18,852	18,289	3,984	1,872	691	423	169	60	24	12	0	1	20,879	14
1976	61,151	25,704	24,606	4,880	2,354	789	487	188	70	26	11	5	1	26,433	20
1977	67,134	24,868	31,298	6,162	2,837	1,130	569	141	66	36	21	6	0	32,511	27
1978	76,121	30,143	34,983	6,405	2,989	1,080	418	67	26	8	0	0	2	31,804	9
1979	105,313	41,191	51,056	7,898	3,306	1,255	477	86	28	13	2	0	1	39,981	21
1980	127,708	47,377	61,808	11,474	4,515	1,537	686	192	98	18	3	0	0	53,796	73
1981	124,506	42,323	63,403	11,766	4,546	1,793	486	93	81	11	2	1	1	54,142	7
1982	129,275	44,893	66,521	10,855	4,686	1,814	432	56	13	4	0	1	0	51,190	2
1983	136,717	51,071	65,545	12,171	5,311	1,950	544	65	16	4	0	0	0	56,471	7

INTERNAL RADIOACTIVITY

Policy and Limits

The Navy's policy on internal radioactivity for personnel associated with the nuclear propulsion program continues to be the same as it was more than two decades ago--to prevent significant radiation exposure to personnel from internal radioactivity. The limits invoked to achieve this objective are one-tenth of the levels allowed by Federal regulations for radiation workers. The results of this program have been that no one has received more than one-tenth the Federal annual internal occupational exposure limits from internal radiation exposure caused by radioactivity associated with Naval nuclear propulsion plants.

The basic Federal limit for radiation exposure to organs of the body from internal radioactivity has been 15 rem per year. There have been higher levels applied at various times for thyroid and for bones; however, use of these specific higher limits has not been necessary in the Naval Nuclear Propulsion Program.

Fifteen rem per year is the limit recommended for most organs of the body by the U. S. National Committee on Radiation Protection in 1954 (ref 1), by the U. S. Atomic Energy Commission in the initial edition of ref (3) applicable in 1957, by the International Commission on Radiological Protection in 1959 (ref 2), and was adopted for Federal agencies when President Eisenhower approved recommendations of the Federal Radiation Council May 13, 1960. Although the International Commission on Radiological Protection revised its recommendations in 1977 (ref 8) to raise limits for most organs, the Naval Nuclear Propulsion Program has not changed the limits.

Source of Radioactivity

Radioactivity can get inside the body through air, through water or food, and through surface contamination via the mouth, skin, or a wound. The radioactivity of primary concern is the metallic corrosion products on the inside surfaces of reactor plant piping systems. These are in the form of insoluble metallic oxides, primarily iron oxides. Ref (12) contains more details on why cobalt 60 is the radionuclide of most concern for internal radioactivity.

The design conditions for reactor fuel are much more severe for warships than for commercial power reactors. As a result of being designed to withstand shock, naval reactor fuel elements retain fission products including fission gases within the fuel. Sensitive measurements are made frequently to verify the integrity of reactor fuel. Consequently, fission products such as strontium 90 and cesium 137 make no measurable contribution to internal exposure of personnel from radioactivity associated with Naval nuclear propulsion plants. Similarly, alpha emitters such as uranium and plutonium are retained within the fuel elements and are not accessible to personnel operating or maintaining a Naval nuclear propulsion plant.

Because of the high integrity of reactor fuel and because soluble boron is not used in reactor coolant for normal radioactivity control in Naval reactors, the amounts of tritium in reactor coolant are far less than in typical commercial power reactors. The small amounts that are present are formed primarily as a result of neutron interaction with the deuterium naturally present in water. The radiation from tritium is of such low energy that the Federal limits for breathing or swallowing tritium are one hundred times higher than for cobalt 60. As a result radiation exposure to personnel from tritium is far too low to measure. Similarly, the low energy beta radiation from carbon 14, which is formed in small quantities in reactor coolant systems as a result of neutron interactions with nitrogen and oxygen, does not add measurable radiation exposure to personnel operating or maintaining Naval nuclear propulsion plants.

Control of Airborne Radioactivity

Airborne radioactivity is controlled in maintenance operations such that masks are not normally required. To prevent exposure of personnel to airborne radioactivity when work might expose radioactivity to the atmosphere, contamination containment tents or bags are used. The areas inside these containments are ventilated to the atmosphere through high efficiency filters which have been tested to remove at least 99.95 percent of particles of a size comparable to cigarette smoke. The occupied area outside these containments is required to be ventilated through high efficiency filters any time work which could cause airborne radioactivity is in progress inside an area such as a reactor compartment. Airborne radioactivity surveys are required to be performed regularly in radioactive work areas. Any time airborne radioactivity above the limit is detected in occupied areas, work which might be causing airborne radioactivity is stopped. This conservative action is taken to minimize internal radioactivity even though the Navy's airborne radioactivity limit would allow continuous breathing for forty hours per week throughout the year to reach an annual exposure to the lungs of one-tenth the Federal limit. Personnel are also trained to use masks when airborne radioactivity above the limit is detected. However, masks are seldom needed and are not relied upon as the first line of defense against airborne radioactivity.

It is not uncommon for airborne radioactivity above the limit to be caused by radon naturally present in the air. Atmospheric temperature inversion conditions can allow this buildup of radioactive particles from radon. Radon can build up above the limit in sealed or poorly ventilated rooms in homes or buildings made of stone. Most cases of airborne radioactivity above the limits in occupied areas in the Naval Nuclear Propulsion Program have been caused by radioactive particles from radon and not from the reactor plant. Procedures have been developed to allow work to continue after it has been determined that the elevated airborne radioactivity is from naturally occurring radon.

Radon is also emitted from radium used for making dials luminous. There have been a number of cases where a single radium dial such as on a wristwatch has caused the entire atmosphere of a submarine to exceed the airborne radioactivity limit used for the nuclear propulsion plant. Radium in any form has been banned from submarines to prevent interference with keeping airborne radioactivity from the nuclear propulsion plant as low as practicable.

Control of Radioactive Surface Contamination

Perhaps the most restrictive regulations in the radiological control program are established in the requirements for the control of radioactive contamination. Work operations involving potential for spreading radioactive contamination use containments to prevent personnel becoming contaminated. The controls for radioactive contamination are so strict that precautions sometimes have had to be taken to prevent tracking contamination from fallout and natural sources into nuclear areas because the contamination control limits used in the nuclear areas were below the levels of fallout and natural contamination occurring outside in the general public areas.

Anticontamination clothing, including coveralls, hood (to cover the head, ears and neck), shoe covers and gloves, is provided when needed. However, the basic approach is to avoid the need for anticontamination clothing by containing the radioactivity. As a result, most work on radioactive materials is performed with hands reaching into gloves installed in containments, making it unnecessary for the worker to wear anticontamination clothing. In addition to providing better control over the spread of radioactivity, this method has reduced radiation exposure since the worker can usually do his job better and faster in his normal work clothing. A basic requirement of contamination control is monitoring all personnel leaving any area where radioactive contamination could possibly occur. Workers are trained to survey themselves, and their performance is checked by radiological control personnel. Personnel monitor before, not after, they wash. Therefore, washing or showering at the exit of radioactive work areas is not required. The basic approach is to prevent contamination, not wash it away.

Surveys for radioactive contamination are taken frequently by trained radiological control personnel. Results of these surveys are reviewed by supervisory personnel to provide a double-check that no abnormal conditions exist. The instruments used for these surveys are checked against a radioactive calibration source daily and prior to use, and they are calibrated at least every six months.

Control of Food and Water

Smoking, eating, drinking and chewing are prohibited in radioactive areas. Aboard ship, drinking water is distilled from seawater by using steam. However, the steam is not radioactive because it is in a secondary piping system separate from the reactor plant radioactive water. In the event radioactivity were to leak into the steam system, sensitive radioactivity detection instruments which operate continuously would give early warning.

Wounds

Skin conditions or open wounds which might not readily be decontaminated are cause for disqualification from doing radioactive work. Workers are trained to report such conditions to radiological control or medical personnel, and radiological control technicians watch for open wounds when workers enter radioactive work areas. In the initial medical examination prior to radiation work and during subsequent examinations, skin conditions are also checked. If the medical officer determines a wound is sufficiently healed or considers the wound adequately protected, he may remove the disqualification.

There have been only a few cases of contaminated wounds in the Naval Nuclear Propulsion Program. In most years, none occurred. Examples of such injuries which have occurred in the past include a scratched hand, a metallic sliver in a hand, a cut finger, and a puncture wound to a hand. These wounds occurred at the same time the person became contaminated. Insoluble metallic oxides which make up the radioactive contamination remain primarily at the wound rather than being absorbed into the blood stream. These radioactively contaminated wounds have been easily decontaminated. No case of a contaminated wound is known where the radioactivity initially present in the wound was as much as one one-thousandth of that permitted for a radiation worker to have in his body.

Monitoring for Internal Radioactivity

The radioactivity of most concern for internal radiation exposure from Naval nuclear propulsion plants is cobalt 60. Although most radiation exposure from cobalt 60 inside the body will be from beta radiation, the gammas given off make cobalt 60 easy to detect. Complex whole body counters are not required to detect cobalt 60 at low levels inside the body. For example, one millionth of a curie of cobalt 60 inside the lungs or intestines will cause a measurement of two times above the background reading with a standard radiation survey instrument. This amount of internal radioactivity will cause the instrument used to monitor personnel for radioactive contamination on their body to reach the alarm level. Every person is required to monitor his entire body every time he leaves an area with radioactive surface contamination. Monitoring the entire body is a requirement in the Naval Nuclear Propulsion Program; monitoring just hands and feet is not permitted. Therefore, if a person had as little as a millionth of a curie of cobalt 60 inside him, it would readily be detected.

Swallowing one millionth of a curie of cobalt 60 will cause internal radiation exposure of about 0.06 rem. The radioactivity will pass through the body and be excreted within a period of a little more than one day.

One millionth of a curie of cobalt 60 deposited in the lungs as a result of an inhalation incident is estimated to cause a radiation exposure of about 3 rem to the lungs over the following year based on standard calculative techniques recommended by the International Commission on Radiological Protection (ref 13). These techniques provide a convenient way to estimate the amount of radiation exposure a typical individual might be expected to receive from small amounts of internally deposited radioactivity. These techniques account for the gradual removal of cobalt 60 from the lungs through biological processes and the radioactive decay of cobalt 60 with a 5.3 year half life. However, if an actual case were to occur, the measured biological elimination rate would be used in determining the amount of radiation exposure received.

In addition to the control measures to prevent internal radioactivity and the whole body monitoring frequently performed on those who work with radioactive materials, more sensitive monitoring is also performed during radioactive overhaul work. Shipyard procedures for monitoring internal radioactivity use the type of scintillation detectors which will reliably detect an amount of cobalt 60 inside the body that is more than one hundred times lower than the one millionth of a curie used in the examples above. Shipyards typically monitor for internal radioactivity as part of each radiation medical examination, performed before an employee initially performs radiation work, after he terminates radiation work, and periodically in between. Shipyards also monitor periodically during the year groups of personnel who did the work most likely to have caused spread of radioactive contamination. Any person who has radioactive contamination above the limit anywhere on the skin of his body during regular monitoring at the exit from a radioactive area is monitored for internal radioactivity with the sensitive detector. Also any person who might have breathed airborne radioactivity above limits is monitored with the sensitive detector.

Results of Internal Monitoring in 1984

During 1984 over 10,000 personnel were monitored for internally deposited radioactivity using sensitive scintillation detectors at the eight shipyards performing work associated with Naval nuclear propulsion plants. Equipment and procedures provide detection of at least 0.01 millionths of a curie. Three persons, who were contaminated during maintenance work, had internal radioactivity above this level in 1984. The three individuals had 0.054 and 0.165, 0.014 and 0.091, and 0.024 and 0.026 millionths of a curie in their lung and gastrointestinal system, respectively. In each case, the radionuclide was insoluble cobalt 60, and within three days, the quantity of internally deposited radioactivity had decreased to less than 0.01 millionth of a curie due to elimination by natural biological processes. The highest exposure among these individuals was 16 mrem to the lower large intestine of one individual as the radioactivity passed through his gastrointestinal system and approximately 24 mrem to the lungs of another individual over his lifetime due to this uptake.

EFFECTS OF RADIATION ON PERSONNEL

Control of radiation exposure in the Naval Nuclear Propulsion Program has always been based on the assumption that any exposure, no matter how small, involves some risk; however, exposure within the accepted exposure limits represents a risk small compared with normal hazards of life. The basis for this statement is presented below.

Exposure to Radiation Involves Some Risk

Since the inception of nuclear power, scientists have cautioned that exposure to ionizing radiation in addition to that from natural background involves some risk. The National Committee on Radiation Protection and Measurements in 1954 (ref 1) and the International Commission on Radiological Protection in 1958 (ref 2) both recommended that exposures should be kept as low as practicable and that unnecessary exposure should be avoided to minimize this risk. The International Commission on Radiological Protection in 1962 (ref 14) explained the assumed risk as follows:

> "The basis of the Commission's recommendations is that any exposure to radiation may carry some risk. The assumption has been made that, down to the lowest levels of dose, the risk of inducing disease or disability in an individual increases with the dose accumulated by the individual, but is small even at the maximum permissible levels recommended for occupational exposure."

The National Academy of Sciences-National Research Council Advisory Committee on the Biological Effects of Atomic Radiation included similar statements in its reports in the 1956-1961 period. In 1960, the Federal Radiation Council stated in ref (4) that its radiation protection guidance did not differ substantially from recommendations of the National Committee on Radiation Protection and Measurements, the International Commission on Radiological Protection, and the National Academy of Sciences.

One conclusion from these reports is that radiation exposures to personnel should be minimized. This is not a new conclusion. It has been a major driving force of the Naval Nuclear Propulsion Program.

Studies of the Effects of Radiation on Humans

Tens of thousands of reports have been written on the effects of radiation. Even the list of summary reports is voluminous. In spite of the fact that there are many unanswered questions concerning the effects of radiation on humans, more is known about radiation than almost any substance that can affect humans. More money has been spent to learn the effects of radiation on humans than for any other hazard in our modern society. In fact, the National Academy of Sciences in ref 15 stated: "It is fair to say that we have more scientific evidence on the hazards of ionizing radiation than most, if not all, other environmental agents that affect the general public."

The main effect is cancer. Effects other than cancer have not been found for low-level radiation exposure to adults. The following brief summary of the effects of low-level whole body external radiation is primarily from refs (15) and (16).

The most important data on the effects of whole body external radiation exposure on humans comes from the almost 30 years of extensive study of the Japanese atomic bomb survivors. In addition, studies have been made of the Marshall Islands inhabitants who received about 12,000 man-rem from fallout in 1954. Studies have been made on groups of patients who have had frequent diagnostic x-ray examinations. Numbers of studies have been made on patients who have had radiation therapy for a disease of the bones of the back and for other conditions. These studies predominantly involved radiation doses of greater than 100 rem. The determinations of damage from doses greater than 100 rem have been reasonably consistent from numerous different studies. Extensive irradiation studies of animals have also been used to show what to look for in humans. These animal studies also show under controlled conditions not available in studies on humans how the radiation effects change with amount and frequency of radiation exposure.

Results of radiation studies on humans show the highest rates of cancer occur in the thyroid and the female breast, although the death rate for thyroid cancer is low. The cancer rates from radiation are lower for leukemia and lung cancer, and lower still for cancers of the bone and other organs. Leukemia has been associated with radiation exposure in almost every study of radiation on humans. Reasons for this include the improved diagnosis of leukemia in recent decades and the low natural incidence of leukemia compared to other cancers. However one type of leukemia, chronic lymphatic leukemia, has not been found in any study to be associated with radiation. Some organs appear to be so resistant to radiation-induced cancer that there has been no clear association between radiation and cancer in these organs. One example is the prostate gland.

One characteristic of cancer caused by low-level radiation is the long delay time between time of radiation exposure and time of diagnosis of cancer. Cancer is not diagnosed until more than a few years have elapsed. In the Japanese atomic bomb survivors, the end of the latent period for leukemia was about 25 years. For the sum of all types of cancers ref (16) assumes that in 25 years one-half the cancers will have occurred.

Cataracts of the eyes can be caused by radiation. However, cataract formation appears to have more evidence of having a threshold radiation dose than any other radiation damage studied. Very high radiation doses have been required to produce cataracts. Ref (15) states that single exposures of 200 to 500 rem or fractionated exposures of 1,000 rem are the threshold exposures required to produce damage to the lens of the eye sufficient to interfere with vision.

Genetic effects can also be caused by radiation. However, genetic effects greater than the natural incidence rate have not been demonstrated in human populations exposed to radiation. Genetic effects are changes in human genes that do not pose a risk to the parent but could cause birth defects in offspring. The current natural rate of genetic effects is approximately 10 percent of all live births and range from trivial effects, such as hair and eye color changes, to more serious disorders. No increase in the natural rate of genetic effects has been found in studies of the 35,000 children conceived by parents irradiated as a result of the nuclear explosions in Hiroshima and Nagasaki in 1945.

Sterility, which is not a genetic effect, can be caused by radiation. However, according to ref (15), the radiation exposure required to cause sterility in males is very high, probably in excess of lethal exposures. Scientific reports of several decades ago speculated that radiation might cause a general effect that would shorten life, similar to aging. Reports in the last decade conclude such an effect has not been found in studies on humans. Nor have numerous other diseases such as heart disease been associated with radiation in these studies. To date the chief effect of radiation on humans has been found to be cancer.

In 1978, Dr. T. Najarian, assisted by the Boston Globe, issued a sensationalized report which alleged that Portsmouth Naval Shipyard (PNS) workers who were occupationally exposed to low-level radiation suffered twice the expected rate of overall cancer deaths and five times the expected rate of leukemia deaths. This report was based on an informal review of several hundred death records, without any official input. It caused a number of frightening news stories. The National Institute for Occupational Safety and Health (NIOSH) was subsequently directed by Congress to investigate Dr. Najarian's report.

Under contract with NIOSH, Dr. Najarian's study was repeated using data the Navy made available to NIOSH. In June 1979, Dr. Najarian testified before Congress on the results of the reanalysis based on official data. In his testimony Dr. Najarian repudiated his earlier findings of increased overall cancer and leukemia. His third finding of increased blood cancers was separately repudiated at that time by the National Cancer Institute.

In December 1980, NIOSH finished their investigation based on approximately 25,000 Portsmouth Naval Shipyard (PNS) workers and issued a final report. This report (ref 17) states that NIOSH found no excess of deaths due to leukemia or other cancers among the Shipyard workers. This report specifically states:

> "No relationship between exposure to radiation and mortality from any cause was observed among the PNS population when compared to the United States white male population. Furthermore, no excess in leukemia mortality was observed in the radiation exposed population when compared to the non-radiation exposed employees of PNS."

In February 1985, NIOSH completed another study (ref 29) called a case-control study which examined the leukemia question at Portsmouth using a more sophisticated method. This study looked at all the leukemia cases (53) compared to a select group of controls (212) who shared common characteristics with the cases. The study concentrated both on exposure to radiation and exposure to solvents. It found that approximately the same proportion of cases and controls received 1 rem or more of radiation dose. A similar finding was made relative to solvents. Thus, NIOSH concluded:

> "No statistically significant positive association of leukemia with either radiation or solvent exposures was found."

Thus, the earlier reports of excess cancer rates among Portsmouth Naval Shipyard workers exposed to low-level radiation were not substantiated by NIOSH.

The Department of Energy is sponsoring a more comprehensive shipyard epidemiologic study. The study is being performed by Johns Hopkins University and will include radiation workers in all shipyards doing Naval nuclear propulsion plant work so that its findings will be based on a much larger population. Because of the size of the study, results are not expected for several years.

Numerical Estimates of Risk from Radiation

In 1972, both the United Nations Scientific Committee on the Effects of Atomic Radiation and the National Academy of Sciences-National Research Council Advisory Committee on the Biological Effects of Ionizing Radiations issued reports (refs 18 and 19) which estimated numerical risks for specific types of cancer from

radiation exposure to humans. In 1977, both the International Commission on Radiological Protection and the United Nations Scientific Committee on the Effects of Atomic Radiation issued reports (refs 8 and 16) reconfirming these risk estimates. The risk estimates from both refs (8) and (16) can be briefly summarized as follows:

> In a large population group (such as 100,000 people) receiving an annual total of 10,000 man-rem year after year, the increased risk from this radiation appears to be in the region of about one fatal cancer case each year and about one leukemia case every five years in excess of the normal numbers of cases.

This can be used to develop a risk estimate for personnel exposed to radiation associated with Naval nuclear propulsion plants. In all shipyards there have been a total of about 126,000 personnel monitored for exposure to radiation, and their exposure rate has averaged less than 5,500 man-rem per year. Therefore, there should be less than one excess fatal cancer per year and less than one excess leukemia case every five years among the total 126,000 shipyard personnel who have ever been monitored for radiation associated with Naval nuclear propulsion plants.

According to refs (8) and (16), this risk estimate is likely to be substantially overstated because the radiation exposures are from gamma radiation at low doses and low dose rates. Also, exposure to neutrons and exposure from internal radioactivity in the Naval Nuclear Propulsion Program are too low to have the confusing effects noted in some studies of the effects of radiation on humans. The National Academy of Sciences National Research Council Committee on Biological Effects of Ionizing Radiation issued a report in 1980 (ref 15) which also stated that the risk estimates in refs (8) and (16) for low-level exposure may be overestimated. This report recommended that the risk of dying of cancer from low-level radiation exposure be estimated based on a model which yields lower risk estimates than those reported in refs (8) and (16). For simplicity, the discussion which follows will use the earlier conservative estimates in refs (8) and (16).

Radiation exposure received by Naval personnel assigned to nuclear-powered ships and their support facilities has averaged less than 2000 man-rem per year. Therefore, according to refs (8) and (16) there should be less than one excess fatal cancer every five years and less than one excess leukemia case every twenty-five years among the approximately 61,900 Naval personnel who have ever been monitored for occupational exposure to radiation associated with Naval nuclear propulsion plants. Since only a few percent of the total man-rem to ship personnel is from neutrons, the same qualifications apply as were mentioned for shipyard personnel, and this risk estimate is likely to be substantially overestimated.

Radiation Exposure Comparisons

To help put this risk estimate in perspective, comparisons are needed. For example, in a typical group of 10,000 people in the U. S., a total of 1600 will die of cancer (ref 20). If each of the 10,000 received over his lifetime one rem more than he was already receiving from background and medical sources, then according to the preceding risk estimate one extra person would die of cancer. Therefore, the 1,600 cancer deaths would increase to 1601 for this group of 10,000. This example is directly applicable to the Naval Nuclear Propulsion Program where the average lifetime occupational radiation exposure is one rem.

However, a few highly controversial studies have concluded that more people would die from radiation than the National Academy of Sciences and United Nations committees predict. If the higher risk estimate of one well known study is applied to the same population group of 10,000, then the 1,600 cancer deaths would increase to 1,610.

The current controversy over effects of low-level radiation is whether one extra rem to each of 10,000 people will cause the normal number of 1,600 cancer deaths to increase to 1,601, or to 1,610. The 1,601 figure is the current best estimate. Studies are now underway to attempt to refine the accuracy of the estimates.

The following examples give further perspective on what radiation exposure means:

- Of all industrial and medical radiation workers in the United States, about 15,000 die each year from cancer. It is estimated that only 25 additional cancer deaths occur per year as a result of radiation exposure from their work.

- Radiation from the nuclear accident at Three Mile Island may add one fatal cancer death to the public within fifty miles. Of the two million people living within this fifty mile radius, more than 300,000 are expected to die of cancer from causes other than the radioactivity released from this accident.

- The average occupational radiation exposure of all those monitored in the Naval Nuclear Propulsion Program is about 0.21 rem per year. This is only slightly greater than the average radiation exposure received in the U. S. each year from natural background and medical x-rays. (Derived from ref 21).

- The average lifetime occupational radiation exposure of one rem for personnel in the Naval Nuclear Propulsion Program is less than one tenth the amount of radiation exposure these same personnel will average over their lifetimes from natural background and medical x-rays. (Derived from ref 21).

- This one rem average lifetime occupational radiation exposure can also be compared very roughly to the 5 rem received in a year from smoking one pack of cigarettes per day. This comparison is not exact because it requires more lung exposure from natural radioactivity in tobacco to cause the same amount of risk as whole body gamma radiation. (ref 22)

- The risk of dying from an automobile accident is forty or more times higher than the risk of fatal cancer for the average person with 1 rem lifetime radiation exposure.

The total occupational radiation exposure of 4,898 man-rem received by all personnel in the Naval Nuclear Propulsion Program in 1984 can be compared to the many other sources of radiation exposure received by the U. S. population. Examples follow:

- 20,000,000 man-rem to the population of the U. S. each year from natural background radiation (ref 21).

- 17,000,000 man-rem to the population of the U. S. each year from medical and dental radiation (ref 21).

- 650,000 man-rem to the population of the U. S. each year from radioactivity in natural gas used for cooking (ref 22).

- 100,000 man-rem the one million inhabitants of Denver could save each year if they moved to a region such as Washington, D. C. with lower natural background radiation levels (Derived from ref 21).

- 12,000 man-rem total to passengers in jet airplane flights in the United States from increased cosmic radiation at the higher altitudes used by jets (ref 23).

Thus, the total occupational radiation exposure received by all personnel in 1984 is about one ten-thousandth of the total radiation exposure received by the U. S. population from all sources. The risk from occupational radiation exposure in the Naval Nuclear Propulsion Program is also less than the risks these same personnel face from natural background radiation or from medical radiation. To demonstrate this, the 126,000 personnel monitored for radiation in all shipyards over the last 31 years will receive about 12,600 man-rem per year from natural background and about the same from medical radiation. The average occupational exposure to this group has been less than 5,500 man-rem per year.

Risk estimates for radiation should also be compared to other risks normally encountered in industrial activities, using the following table for example:

DEATH RATES IN U. S. FOR VARIOUS CAUSES

CAUSE	ANNUAL DEATHS PER 100,000 POPULATION
Smoking (ref 24)	150
Motor Vehicle accidents (ref 25)	22
Work accidents (ref 25)	
Mining, quarrying	63
Construction	57
Agriculture	54
Transportation and Public Utilities	31
All Industries Average	14
Government	11
Services	9
Manufacturing	9
Trade	6
Industrial accidents in a Naval Shipyard (eight shipyards 1972-1977)	7
Commercial air travel (ref 25)	1
Coal-fired electric power (estimate derived from ref 26)	1 to 10
Radiation associated with Naval Nuclear propulsion plants (risk estimate)	Less than 1

Because of these estimates on the risk of low-level radiation, extra hazard pay for radiation work has never been paid in the Naval Nuclear Propulsion Program. Civil Service Commission regulations do not provide for hazard pay for radiation work. A serious disadvantage to extra pay for radiation risks is that it would tend to increase the difficulty in minimizing radiation exposure because some personnel would press for more radiation to maximize their pay.

Extrapolations

In radiation, as in other areas, a most effective way to frighten people is to proclaim that no one knows what the effects are. This has been repeated so often that it has almost become an article of faith that no one knows the effects of low-level radiation on humans.

One could well state, "No one knows the risks of smoking a few cigarettes," but the risks of smoking a large number of cigarettes are well known. If 10,000 people smoke an average of four cigarettes a day, about 100 deaths will result; data are not available for lower smoking rates. For radiation, doses of 100 rem to each of 10,000 people would be required to cause an equal number of deaths. The effects of radiation on humans at

doses of 100 rem are well known. The controversy over radiation risks today is how to extend the risk estimates to even lower levels. As we get to lower levels, it becomes more and more difficult to detect the effects.

The figures just presented can be extended to show that one rem has about the same risk of death as smoking one cigarette per month. This comparison is only to show that finding out the effect on the death rate of one rem of exposure is about the same as trying to find out the effect of smoking one cigarette a month.

In summary, the effect of one rem is extremely small. There are physical limits to how far scientists can go to ascertain precisely the size of this risk, but it is known to be small. Instead of proclaiming how little is known about low-level radiation, it is more appropriate to emphasize how much is known about the small actual effects.

Conclusions on the Effects of Radiation on Personnel

This perspective provides a better position to answer the question, "Is radiation safe?" If safe means zero effect, then the conclusion would have to be that radiation is unsafe. But to be consistent, background radiation and medical radiation would also have to be considered unsafe. Or more simply, being alive is unsafe.

"Safe" is a relative term. Comparisons are necessary for actual meaning. For a worker, safe means the risk is small compared to other risks accepted in normal work activities. Aside from work, safe means the risk is small compared to other risks routinely accepted in life.

Each recommendation on limits for radiation exposure from the key organizations referenced has emphasized the need to minimize radiation exposure. Thus, the Navy is committed to keeping radiation exposure to personnel as low as reasonably achievable. No level of radiation exposure has been identified for which responsible organizations have stated there is no effect. Similarly it is difficult to find a single activity of man for which one can confidently state the risk is zero. However, the above summaries show that the risk from radiation exposure associated with Naval nuclear propulsion plants is low compared to hazards normally accepted in industrial work and in daily life outside of work.

CLAIMS FOR RADIATION INJURY TO PERSONNEL

Personnel who consider they have or might have had occupational injury may file claims. Naval shipyard personnel are employees of the U. S. Government and therefore file claims with the U. S. Department of Labor's Office of Workmen's Compensation. Shipyards hold no hearings on injury claims. They are not handled in an adversary procedure. The Navy has no rights to present a case to the Labor Department. The claim does not even have to be filed through the shipyard. The shipyard is not permitted to appeal a decision, but the employee may appeal. The primary consideration in the Federal laws and procedures set up for injury compensation is to take care of the Federal employee. The program to compensate Federal employees is well publicized.

In private shipyards injury compensation claims are handled under the Longshoreman's and Harbor Workers' Compensation Act. The claim may be handled through the shipyard's insurance carrier or by a U. S. Department of Labor claims examiner. Either the employee or the employer may appeal.

Claims for military personnel concerning prior duty are handled through the Veterans Administration.

There have been a total of 156 claims filed for injury from radiation associated with Naval nuclear propulsion plants. One-hundred originated from employees of the six Naval shipyards, thirty-five from private shipyards and twenty-one from Navy personnel. These claims are summarized in Table 7. As shown in Table 7 more than half the claims have been filed for injuries other than cancer or leukemia. Three-fourths of the claims filed for cancer or leukemia involved workers with lifetime radiation exposures less than the 5 rem, which is the exposure a nuclear worker is permitted to receive in one year by Federal Regulations.

Six claims have been awarded, two for leukemia in 1968 and 1979, three for cataracts of the eyes in 1971, 1974 and 1977, and one for leukocytosis in 1969. The Navy considers all six of these awards were unjustified:

- One leukemia case had an occupational exposure of 5.38 rem. The claimant had also received hundreds of rem in medical radiation exposure for adenoids. If radiation were to be selected as the cause of this leukemia, then the occupational exposure could not have been more than a tiny part of the total radiation exposure.

- The second leukemia case had a total occupational exposure of 1.00 rem. This amount of radiation exposure is small and less than 10 percent of the amount of exposure the claimant will receive during his life from natural background and medical radiation.

- Two of the cataract cases had total lifetime radiation exposures of about 3 rem, and one case had less than 1 rem. These exposures are hundreds of times smaller than needed to produce cataracts in the eyes.

- The leukocytosis (elevated white blood cell count) case had a total occupational exposure of 15.5 rem which was received over an eight year period. This case was evaluated by the medical research center of a national laboratory, which concluded that the cause of the leukocytosis was unknown. In addition, leukocytosis has not been shown to be associated with low-level occupational radiation exposure.

In addition to the above claims, three suits have been filed in court alleging injury from radiation. One suit involves leukemia; another a cancer; and the third does not involve a cancer. All three have been resolved.

From the radiation injury claims filed to date, the Navy has been unable to draw any conclusions concerning radiation injury to personnel occupationally exposed to radiation associated with Naval nuclear propulsion plants.

TABLE 7

CLAIMS FOR RADIATION INJURY TO PERSONNEL

Injury Claimed	Claims Filed	Claims Awarded	Claims Denied or Deferred	Claims Active
Leukemia	24	2	15	7
Cancer Other Than Leukemia	45	0	33	12
Other	87	4	68	15
TOTAL	156	6	116	34

AUDITS AND REVIEWS

Checks and cross-checks, audits, and inspections of numerous kinds have been shown to be essential in maintaining high standards of radiological control. First, each worker is specially trained in radiological control as it relates to his own job. Second, written procedures exist which require verbatim compliance. Third, radiological control technicians and their supervisors oversee radioactive work. Fourth, personnel independent of radiological control technicians are responsible for personnel radiation exposure records.

Fifth, a strong independent audit program is required covering all radiological control requirements. In all shipyards this radiological audit group is independent of the radiological control organization and its findings are reported regularly to senior shipyard management, including the shipyard commander. This group performs continuing surveillance of radioactive work. It conducts in-depth audits of specific areas of radiological control. This group checks all radiological control requirements at least annually.

Sixth, the U. S. Department of Energy assigns to each shipyard a representative who reports to the Director of the Naval Nuclear Propulsion Program at headquarters. One assistant to this representative is assigned full time to audit and review radiological controls, both in nuclear-powered ships and in the shipyard. Seventh, Naval Nuclear Propulsion Program headquarters personnel conduct periodic inspections of radiological control in each shipyard. Similarly, there are multiple levels of audits and inspections for the other Naval shore facilities, tenders, and nuclear-powered ships.

In addition, various aspects of the Naval Nuclear Propulsion Program have been reviewed by other Government agencies. For example, the National Institute for Occupational Safety and Health conducted an evaluation of the radiological controls program at Portsmouth Naval Shipyard in conjunction with its mortality study at the shipyard (discussed earlier in this report). NIOSH published the results of its evaluation in a report (ref 27) in April 1983, which stated the following conclusions (quoted verbatim):

- The employee dose data provided NIOSH by Portsmouth Naval Shipyard is complete and provides a reasonable estimate of the individual worker's dose.
- The Portsmouth Naval Shipyard personnel dosimetry program provides accurate internal and external dose data.
- The external and internal doses received by Portsmouth Naval Shipyard personnel are low compared to present occupational exposure guidelines.

- The probability of unreported accidents/incidents or undocumented exposures is extremely small.
- The radiological controls employed are adequate to protect the worker from internal and external hazards.
- The impact of the nuclear work at Portsmouth Naval Shipyard to the surrounding environment is minimal or negligible.
- Nuclear operations at Portsmouth Naval Shipyard are not contributing a significant radiation dose to the general public.

ABNORMAL OCCURRENCES

It is a fact of human nature that people make mistakes. The key to a good radiological control program is to find the mistakes while they are small and prevent the combinations of mistakes that lead to more serious consequences The preceding section on inspections supports the contention that the Natural Nuclear Propulsion Program gives more attention to errors and their prevention than to any other single subject. Requiring constant focus on improving performance of radiological work has proven effective in reducing errors.

In addition, radiological control technicians are authorized and required to stop anyone performing work in a manner which could lead to radiological deficiencies. One definition of "deficiency" is a failure to follow a written procedure verbatim. However, the broadest interpretation of the term "deficiency" is used in the Navy's radiological control program. Anything involved with radiation or radioactivity which could have been done better is also considered a radiological deficiency.

Radiological deficiencies receive management attention. But there is a higher level of deficiency that is defined as a radiological incident. Incidents receive further management review, including evaluation by senior personnel at headquarters and review by the Director of the Naval Nuclear Propulsion Program. Improvement programs over the years have constantly aimed at reducing the numbers of radiological incidents. As improvements occurred, the definition of what constituted an incident was changed to define smaller deficiencies as incidents. These changes were necessary so that the incident reporting system would continue to play a key role in upgrading radiological controls. As a result, it is not practicable to measure performance merely by counting numbers of radiological incidents or deficiencies.

The Department of Energy and its predecessors have used a separate reporting system that has been nearly constant over time and therefore can be used as a basis for comparison. This system uses levels of severity to define radiological occurrences (ref 28). Examples of radiation exposure incidents in each type follow:

- Type A - individual external radiation exposure over 25 rem in one incident or one year
- Type B - individual external radiation exposure over 5 rem in one quarter year
- Type C - external whole body radiation exposure over 3 rem in one quarter year

The Nuclear Regulatory Commission also has criteria defining abnormal occurrences. The Navy regularly evaluates radiological events using these criteria for comparison; results are reported in Table 8.

TABLE 8

ABNORMAL OCCURRENCES
IN THE NAVAL NUCLEAR PROPULSION PROGRAM

Year	Number of Abnormal Occurrences*
1975	0
1976	0
1977	0
1978	0
1979	0
1980	0
1981	0
1982	0
1983	0
1984	0

*Abnormal occurrences are reported here if the Navy evaluation determines they meet either the Department of Energy criteria for Type A radiation exposure incidents or the Nuclear Regulatory Commission criteria for quarterly report to Congress as abnormal radiation exposure occurrences.

The policy of the Navy is to provide for close cooperation and effective communication with state radiological officials involving occurrences that might cause concern because of radiological effects associated with the ships or shore facilities. The Navy has reviewed radiological matters with state radiological officials in the states where Naval nuclear-powered ships are based or overhauled. Although there were no recent occurrences which resulted in radiological effects to the public outside these facilities or which resulted in radiological injury to residents of the states working inside these facilities, states were notified when inquiries showed public interest in the possibility such events had occurred.

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INDEX

	Page
Statement of Adm. Kinnaird R. McKee	1
Adequacy of competition	11
Advanced fleet reactor	16
Akula latest Soviet design	3
Budget change from fiscal year 1985	16
Budget request, fiscal year 1986	11
Combustion engineering	13, 14, 23, 24
Competition:	
Adequacy of industrial base	13
Contractors	12
Evolution of present industrial base	13
Heavy equipment manufacturers	12
Prime contractors	12, 13
Standardization—need for	15
Component costs	23
Core life	18, 19
Curriculum at nuclear power school	5
Dallas	2
Design standardization	15
Disposal procedures for radioactive waste	20, 21
Environmental monitoring and disposal of radioactive wastes from U.S. Naval Nuclear Powered ships and their support facilities	72
Executive Order No. 12344	65
Enactment into law	65
Fleet Operations	10
Fuel manufacturing facility	19
Industrial base	13
Introductory remarks	1
Lawsuit—Curtiss Wright	14, 17, 18
Nautilus	8, 21
NRC obligation to provide technical advice on health and safety matters when requested by DOD	56
Nuclear power school	5
Officers; program sources	9
Occupational Radiation Exposure from U.S. Naval Nuclear Propulsion Plants and their support facilities	140
Personnel	3, 4, 9, 10
Characteristics of nuclear program personnel	3
Headquarters personnel	9
Training	5, 7
Prepared statement of Adm. Kinnaird R. McKee	25
Program sources for nuclear officers	10
Reactor operating characteristics	6
Refueling schedule for prototypes	17
Retention of Personnel	2
Review of responsibilities and authorities of the Office of Naval Reactors, Department of Energy for overseeing naval nuclear propulsion reactors, when requested by DOD	56
Savannah River costs	19
Simulators	8, 19
Soviet:	
Developments	2
Submarines	3, 21
SSN-21:	
Naming	20

Page

Statement of Adm. Kinnaird R. McKee—Continued
SSN-21—Continued
First deployment of 22
Submarine:
Construction 21, 22
Disposal 20
Improvements 22
Technical data; control of 14
Theodore Roosevelt 2
Training on operating reactors 7, 8
Moored training ship 8
Vendor base 17

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